

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 127 (IN TWO PARTS), PART I

Charles D. and Mary Vaux Walcott
Research Fund

CHAZYAN AND RELATED BRACHIOPODS

PART I, TEXT

(WITH 269 PLATES, IN PART II)

By

G. ARTHUR COOPER

Curator of Invertebrate Paleontology and Paleobotany
United States National Museum
Smithsonian Institution



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BY
G. ARTHUR COOPER

Professor of Invertebrate Paleontology and Paleogeography
United States National Museum
Smithsonian Institution



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CONTENTS

| | Page |
|---|------|
| Section I. The formations..... | I |
| Introduction and stratigraphic setting..... | I |
| Background for the studies..... | 2 |
| Building the collection..... | 2 |
| Gifts to the Museum..... | 3 |
| Borrowed material | 3 |
| Preparing the fossils..... | 3 |
| Acknowledgments | 4 |
| Location of types and abbreviations..... | 6 |
| Notes on the correlation chart..... | 6 |
| Geographic and geologic setting of the formations..... | 9 |
| 1. Newfoundland | 11 |
| Table Head series..... | 11 |
| Correlation of Table Head series..... | 11 |
| Long Point series..... | 12 |
| Correlation of Long Point series..... | 13 |
| Cow Head breccia..... | 13 |
| Humber Arm series..... | 13 |
| 2. St. Lawrence and Ottawa Valleys and adjacent areas..... | 13 |
| Mingan Islands | 13 |
| Mingan formation | 13 |
| Correlation of Mingan formation..... | 14 |
| Quebec City region..... | 14 |
| Quebec City formation..... | 15 |
| Montreal and vicinity..... | 15 |
| St. Martin formation..... | 16 |
| Pamelia formation | 16 |
| Lowville formation | 16 |
| Chaumont formation | 16 |
| Ottawa Valley, vicinity of Ottawa..... | 17 |
| Aylmer formation | 17 |
| Rockcliffe member of Aylmer formation..... | 17 |
| St. Martin member of Aylmer formation..... | 17 |
| Correlation of Aylmer formation..... | 17 |
| Ottawa group (or formation)..... | 18 |
| Pamelia formation | 18 |
| Correlation of Pamela formation..... | 18 |
| Lowville formation | 19 |
| Correlation of Lowville formation..... | 19 |
| Chaumont formation | 19 |
| Correlation and discussion of faunal list..... | 20 |
| Rockland formation | 20 |
| Correlation of Rockland formation and remarks on the listed brachiopods.. | 22 |
| Head of the St. Lawrence Valley in New York and adjacent Canada..... | 22 |
| Pamelia formation | 22 |
| Lowville formation | 23 |
| Chaumont formation | 24 |

| | Page |
|---|------|
| Rockland formation | 24 |
| Selby member of Rockland formation..... | 24 |
| Napanee member of Rockland formation..... | 25 |
| Section at Coboconk, central Ontario..... | 25 |
| Shadow Lake formation..... | 25 |
| Gull River formation..... | 25 |
| Moore Hill formation..... | 26 |
| Coboconk formation | 26 |
| Manitoulin Island region..... | 26 |
| Lowville formation | 27 |
| Swift Current formation..... | 27 |
| Cloche Island formation..... | 27 |
| 3. Champlain, Mohawk, and Hudson Valleys..... | 27 |
| Champlain Valley (west side)..... | 27 |
| Day Point formation..... | 28 |
| Correlation of Day Point formation..... | 28 |
| Crown Point formation..... | 28 |
| Correlation of Crown Point formation..... | 29 |
| Valcour formation | 29 |
| Correlation of Valcour formation..... | 29 |
| Lowville formation | 29 |
| Chaumont formation | 30 |
| Amsterdam formation | 30 |
| Isle la Motte formation | 30 |
| Correlation of Isle la Motte formation..... | 30 |
| Phillipsburg thrust slice..... | 31 |
| Champlain Valley (east side)..... | 31 |
| Correlation of formations on the east side of the Champlain Valley..... | 32 |
| Lower Mohawk and Upper Hudson Valleys..... | 32 |
| Amsterdam formation (Mohawk limestone of Conrad)..... | 32 |
| Correlation of Amsterdam formation..... | 33 |
| Isle la Motte formation..... | 33 |
| Hudson Valley region (Albany to Poughkeepsie)..... | 33 |
| Normanskill formation | 33 |
| Mount Merino member..... | 33 |
| Austin Glen member..... | 34 |
| Rysedorf conglomerate | 34 |
| Vicinity of Poughkeepsie, N. Y..... | 35 |
| Vicinity of North Cambridge, N. Y..... | 36 |
| 4. The Appalachians (Pennsylvania to Alabama)..... | 36 |
| Facies in the Appalachians..... | 38 |
| Arline formation | 41 |
| Correlation of Arline formation..... | 43 |
| Athens formation | 43 |
| Correlation and fossils of Athens formation..... | 44 |
| Attalla formation | 45 |
| Bacon Bend member of Sevier formation..... | 45 |
| Bays formation | 45 |
| Correlation of Bays formation | 45 |
| Benbolt formation | 45 |
| Benbolt formation in Virginia | 46 |
| Benbolt formation in Tennessee | 46 |
| Faunal discussion and correlation of Benbolt formation..... | 47 |

| | Page |
|--|------|
| Benner limestone | 48 |
| Ben Hur formation..... | 48 |
| Blackford formation | 48 |
| Blockhouse formation | 49 |
| Botetourt formation | 49 |
| Correlation of Botetourt formation..... | 50 |
| Bowen formation | 50 |
| Burkes Garden member of Benbolt formation..... | 50 |
| Cane Creek formation..... | 51 |
| Carlim limestone | 51 |
| Centre Hall member of Nealmont formation..... | 52 |
| Chambersburg formation | 52 |
| Chatham Hill formation..... | 53 |
| Correlation of Chatham Hill formation..... | 53 |
| Chickamauga limestone | 53 |
| Chota formation | 56 |
| Clifffield formation | 56 |
| Clifffield group | 56 |
| Clover member of Loysburg formation..... | 56 |
| Collierstown formation | 56 |
| Correlation of Collierstown formation | 56 |
| Columbiana formation | 57 |
| Curtin formation | 57 |
| Dot formation | 57 |
| Correlation of Dot formation..... | 57 |
| Douglas Lake member of Lenoir formation..... | 57 |
| Doylesburg member of Shippensburg formation..... | 57 |
| Correlation of Doylesburg member..... | 58 |
| Dryden formation | 58 |
| Edinburg formation | 59 |
| Effna formation | 60 |
| Correlation of Effna formation..... | 61 |
| Eggleston formation | 61 |
| Eidson member of Lincolnshire formation..... | 61 |
| Ellett formation | 62 |
| Elway formation | 62 |
| Correlation of Elway formation..... | 62 |
| Eyer member of Hatter formation..... | 62 |
| Correlation of Eyer member..... | 63 |
| Fannettsburg member of Shippensburg formation..... | 63 |
| Correlation of Fannettsburg member..... | 63 |
| Farragut formation | 63 |
| Correlation of Farragut formation..... | 64 |
| Fetzer tongue of Arline formation..... | 64 |
| Five Oaks formation..... | 64 |
| Fleanor formation | 65 |
| Correlation of Fleanor formation..... | 65 |
| Gratton formation | 65 |
| Grazier member of Hatter formation..... | 65 |
| Correlation of Grazier member..... | 65 |
| Greencastle bed | 65 |
| Hardy Creek formation..... | 65 |
| Hatter formation | 66 |

| | Page |
|--|------|
| Heiskell shale | 66 |
| Hermitage formation | 66 |
| Hogskin member of Lincolnshire formation | 66 |
| Holston limestone | 67 |
| Hostler member of Hatter formation | 68 |
| Correlation of Hostler member | 68 |
| Housum member of Mercersburg formation | 69 |
| Hurricane Bridge formation | 69 |
| Correlation of Hurricane Bridge formation | 69 |
| Jacksonburg formation | 69 |
| Correlation of upper Jacksonburg formation | 70 |
| Kauffman member of Mercersburg formation | 70 |
| Lantz Mills facies of Edinburg formation | 71 |
| Correlation of lower Lantz Mills facies | 71 |
| Correlation of upper Lantz Mills facies | 71 |
| Lemont member of Carlisle formation | 71 |
| Lenoir formation | 72 |
| Correlation of restricted Lenoir formation | 72 |
| Liberty Hall facies of Edinburg formation | 73 |
| Correlation of Liberty Hall facies | 73 |
| Lincolnshire formation | 73 |
| Correlation of Lincolnshire formation | 74 |
| Little Oak formation | 74 |
| Correlation of Little Oak formation | 75 |
| Long Savannah formation | 75 |
| Loysburg formation | 76 |
| Mahan formation | 76 |
| Marcum formation | 76 |
| Martin Creek formation | 77 |
| Martinsburg formation | 77 |
| Meadow marble | 78 |
| Mercersburg formation | 78 |
| Moccasin formation | 78 |
| Mosheim formation (= facies) | 78 |
| Murat formation | 79 |
| Nealmont formation | 79 |
| New Market formation | 79 |
| Oak Hall member of Nealmont formation | 80 |
| Ooltewah formation | 80 |
| Oranda formation | 81 |
| Correlation of Oranda formation | 82 |
| Ottosee formation (= facies) | 82 |
| Paperville formation | 82 |
| Peery formation | 83 |
| Pelham limestone | 83 |
| Pinesburg member of Shippensburg formation | 83 |
| Correlation of Pinesburg member | 84 |
| Poteet formation | 84 |
| Correlation of Poteet formation | 85 |
| Pratt Ferry formation | 85 |
| Correlation of Pratt Ferry formation | 86 |
| Red Knobs formation | 86 |
| Correlation of Red Knobs formation | 86 |

| | Page |
|---|------|
| Rich Valley formation..... | 86 |
| Rob Camp formation..... | 87 |
| Rockdell formation | 87 |
| Rodman member of Nealmont formation..... | 87 |
| Correlation of Rodman member..... | 88 |
| Row Park formation..... | 88 |
| Correlation of Row Park formation..... | 88 |
| St. Clair facies of Murfreesboro formation..... | 88 |
| St. Luke member (facies) of Edinburg formation..... | 89 |
| Correlation of St. Luke member..... | 89 |
| St. Paul group..... | 89 |
| Salona formation | 89 |
| Sevier formation (= facies)..... | 90 |
| Shannondale member of Benbolt formation..... | 90 |
| Shippensburg formation | 91 |
| Snyder member of Benner formation..... | 91 |
| Speers Ferry formation..... | 91 |
| Stones River group..... | 91 |
| Stover member of Benner formation..... | 92 |
| Strasburg formation | 92 |
| Surgener formation | 93 |
| Tellico formation | 93 |
| Thompson Valley formation..... | 94 |
| Toqua formation | 94 |
| Tumbez formation | 94 |
| Valentine member of Curtin formation..... | 94 |
| Valley View member of Curtin formation..... | 94 |
| Vestal marble | 94 |
| Walker Mountain sandstone member of Moccasin formation..... | 95 |
| Ward Cove formation..... | 95 |
| Correlation of Ward Cove formation..... | 96 |
| Wardell formation | 96 |
| Correlation of Wardell formation..... | 97 |
| Wassum formation | 97 |
| Whistle Creek formation..... | 97 |
| Correlation of Whistle Creek formation..... | 97 |
| Whitesburg formation | 97 |
| Witten formation | 98 |
| Correlation of Witten formation..... | 98 |
| Woodway formation | 99 |
| Yellow Branch member of Poteet formation..... | 99 |
| 5. The Central Basin of Tennessee, Wells Creek Basin and High Bridge, Kentucky. | 99 |
| Central Basin of Tennessee..... | 100 |
| Murfreesboro formation | 100 |
| Correlation of Murfreesboro formation..... | 100 |
| Pierce formation | 100 |
| Correlation of Pierce formation..... | 100 |
| Ridley formation | 101 |
| Correlation of Ridley formation..... | 101 |
| Lebanon formation | 101 |
| Correlation of Lebanon formation..... | 102 |
| Carters formation (originally Carters Creek)..... | 102 |
| Correlation of Carters formation..... | 103 |

| | Page |
|---|------|
| “Kimmswick” limestone | 103 |
| Correlation of “Kimmswick” limestone..... | 103 |
| Hermitage formation | 103 |
| Wells Creek Basin..... | 104 |
| High Bridge, central Kentucky..... | 105 |
| Camp Nelson formation..... | 105 |
| Correlation of Camp Nelson formation..... | 105 |
| Oregon formation | 106 |
| Tyrone formation | 106 |
| Correlation of Tyrone formation..... | 106 |
| 6. The disturbed area at Kentland, Indiana..... | 106 |
| Correlation of strata of Kentland area..... | 107 |
| 7. The Mississippi Valley..... | 108 |
| Upper Mississippi Valley..... | 108 |
| St. Peter sandstone..... | 108 |
| Platteville formation | 108 |
| Glenwood member of Platteville formation..... | 109 |
| Pecatonica member of Platteville formation..... | 109 |
| McGregor member of Platteville formation..... | 109 |
| Mifflin member of Platteville formation..... | 110 |
| Magnolia member of Platteville formation..... | 110 |
| Quimbys Mill member of Platteville formation..... | 110 |
| Correlation of Platteville formation..... | 110 |
| Decorah formation | 110 |
| Spechts Ferry member of Decorah formation..... | 110 |
| Correlation of Spechts Ferry member..... | 111 |
| Guttenberg member of Decorah formation..... | 111 |
| Correlation of Guttenberg member..... | 112 |
| Ion member of Decorah formation..... | 112 |
| Correlation of Ion member..... | 112 |
| Prosser formation | 113 |
| Upper Mississippi Valley formations not in general use..... | 113 |
| Lowell Park member of Platteville formation..... | 113 |
| Minneapolis limestone | 113 |
| Beloit dolomite formation..... | 113 |
| Middle Mississippi Valley..... | 113 |
| Buffalo River series..... | 113 |
| Rock Levee formation..... | 114 |
| Plattin group | 114 |
| Bloomsdale formation | 114 |
| Beckett formation | 114 |
| Hager formation | 115 |
| Correlation of Hager formation..... | 115 |
| Macy formation | 115 |
| Hook member of Macy formation..... | 115 |
| Zell member of Macy formation..... | 116 |
| Correlation of Macy formation..... | 116 |
| Barnhart formation | 116 |
| Correlation of Barnhart formation..... | 116 |
| Auburn chert | 117 |
| Correlation of Auburn chert..... | 117 |

| | Page |
|---|------|
| Northern Arkansas | 117 |
| Everton-Jasper formation | 117 |
| Correlation of Everton-Jasper formation..... | 117 |
| Plattin formation | 117 |
| 8. The Arbuckle and Wichita Mountains, Oklahoma..... | 118 |
| Joins formation | 118 |
| Oil Creek formation..... | 119 |
| McLish formation | 119 |
| Tulip Creek formation..... | 120 |
| Correlation of Tulip Creek formation..... | 120 |
| Bromide formation | 120 |
| Mountain Lake member of Bromide formation..... | 120 |
| Pooleville member of Bromide formation..... | 121 |
| Correlation of Bromide formation..... | 123 |
| Viola formation | 123 |
| Womble (Stringtown) formation of Arkansas and Oklahoma..... | 125 |
| 9. The Black Hills, South Dakota..... | 125 |
| Whitewood formation | 125 |
| 10. The Great Basin—Nevada and California..... | 125 |
| Antelope Valley and Toquima Range..... | 126 |
| Pogonip group | 126 |
| Eureka group | 127 |
| Pioche District, Nevada..... | 129 |
| Tank Hill formation..... | 129 |
| California | 129 |
| Mazourka formation | 129 |
| Barrel Spring formation..... | 129 |
| 11. Formations in Utah..... | 130 |
| Ibex area, Utah..... | 130 |
| Northeastern Utah | 130 |
| Swan Peak quartzite..... | 130 |
| Section II. The fossils | 131 |
| General discussion of the fossils..... | 131 |
| Concept of family and genus..... | 131 |
| Shell structure | 131 |
| Notes on evolution..... | 132 |
| Gastrocaulia | 132 |
| Pygocaulia | 133 |
| Annotated list of genera and species..... | 138 |
| Subclass Gastrocaulia | 187 |
| Superfamily Dictyoninacea | 187 |
| Family Micromitridae | 187 |
| Order Atremata | 189 |
| Superfamily Obolacea | 189 |
| Family Obolidae | 189 |
| Subfamily Obolinae | 189 |
| Subfamily Lingulellinae | 195 |
| Subfamily Acanthamboniinae | 211 |
| Subfamily Glossellinae | 213 |
| Superfamily Trimerellacea | 229 |
| Family Trimerellidae | 229 |
| Family Lingulasmaticidae | 232 |
| Family Paterulidae | 236 |

| | Page |
|-----------------------------------|------|
| Superfamily Acrotretacea | 245 |
| Family Acrotretidae | 245 |
| Subfamily Acrotretinae | 245 |
| Superfamily Siphonotretacea | 263 |
| Family Siphonotretidae | 263 |
| Superfamily Discinacea | 270 |
| Family Trematidae | 270 |
| Family Discinidae | 275 |
| Subfamily Orbiculoideinae | 275 |
| Superfamily Craniacea | 282 |
| Family Craniidae | 282 |
| Subclass Pygocaulia | 292 |
| Suborder Orthoidea | 292 |
| Superfamily Orthacea | 292 |
| Family Orthidae | 292 |
| Subfamily Orthinae | 293 |
| Subfamily Productorthinae | 333 |
| Family Hesperonomiidae | 336 |
| Family Orthidiellidae | 338 |
| Family Hesperorthidae | 343 |
| Subfamily Hesperorthinae | 343 |
| Subfamily Glyptorthinae | 361 |
| Family Anomalorthidae | 391 |
| Family Dinorthidae | 393 |
| Family Plectorthidae | 446 |
| Subfamily Plectorthinae | 446 |
| Family Skenidiidae | 491 |
| Suborder Clitambonitoidea | 511 |
| Superfamily Clitambonitacea | 511 |
| Family Tritoechiidae | 511 |
| Subfamily Tritoechinae | 512 |
| Subfamily Polytoechinae | 512 |
| Family Clitambonitidae | 516 |
| Subfamily Atelelasmatinae | 516 |
| Family Kullervoidae | 526 |
| Superfamily Triplesiacea | 529 |
| Family Triplesiidae | 529 |
| Suborder Syntrophioidea | 559 |
| Superfamily Syntrophicea | 559 |
| Family Syntrophopsidae | 559 |
| Family Brevicameridae | 560 |
| Family Camerellidae | 562 |
| Subfamily Camerellinae | 562 |
| Subfamily Stenocamarinae | 602 |
| Family Parastrophinidae | 604 |
| Subfamily Parastrophininae | 604 |
| Family Porambonitidae | 608 |
| Suborder Pentameroidea | 611 |
| Superfamily Pentameracea | 611 |
| Family Parallelelasmataidae | 611 |
| Superfamily Rhynchonellacea | 617 |

| | Page |
|--------------------------------------|------|
| Family Protorynchiidae | 617 |
| Subfamily Protorhynchiinae | 617 |
| Subfamily Ancistrorhynchiinae | 618 |
| Family Rhynchotrematidae | 628 |
| Family Lepidocyclusidae | 657 |
| Family Oligorhynchiidae | 658 |
| Family Orthorhynchulidae | 669 |
| Superfamily Atrypacea | 669 |
| Family Atrypidae | 669 |
| Subfamily Zygospirinae | 669 |
| Subfamily Glassiinae | 690 |
| Superfamily Spiriferacea | 693 |
| Family Cyclospiridae | 693 |
| Suborder Strophomenoidea | 697 |
| Superfamily Plectambonitacea | 697 |
| Family Taffiidae | 697 |
| Family Plectambonitidae | 699 |
| Subfamily Plectellinae | 699 |
| Family Leptestiidae | 700 |
| Subfamily Leptestiinae | 700 |
| Subfamily Isophragminae | 733 |
| Family Taphrodontidae | 740 |
| Family Syndielasmaticidae | 742 |
| Family Leptellinidae | 744 |
| Subfamily Hesperomeninae | 744 |
| Subfamily Leptellininae | 746 |
| Subfamily Leptelloidinae | 763 |
| Family Bimuriidae | 764 |
| Family Sowerbyellidae | 774 |
| Subfamily Sowerbyellinae | 774 |
| Subfamily Xenambonitinae | 813 |
| Subfamily Ptychoglyptinae | 815 |
| Superfamily Strophomenacea | 820 |
| Family Leptaenidae | 820 |
| Family Christianiidae | 859 |
| Family Strophomenidae | 866 |
| Suborder Dictyonelloidea | 947 |
| Family Eichwaldiidae | 947 |
| Suborder Dalmanelloidea | 947 |
| Superfamily Dalmanellacea | 947 |
| Family Dalmanellidae | 947 |
| Family Onniellidae | 953 |
| Family Paurorthidae | 964 |
| Family Heterorthidae | 976 |
| Subfamily Harknessellinae | 976 |
| Family Linoporellidae | 979 |
| Family Schizophoriidae | 985 |
| Subfamily Schizophoriinae | 985 |
| Genus and species undet. | 1006 |
| Bibliography | 1007 |
| Index | 1019 |
| Explanation of plates, Part II | 1025 |

ILLUSTRATIONS

PLATES

(All plates in Part II, following page 1246.)

1. Lingulella, Obolus, Pseudolingula, Westonia.
2. Ectenoglossa, Lingulella, Obolus, Spinilingula.
3. Ectenoglossa, Glossella, Glyptoglossa, Lingulella, Pseudolingula.
4. Ectenoglossa, Glossella, Lingulella.
5. Glossella, Lingulella, Pachyglossa, Pseudolingula.
6. Ectenoglossa, Lingulella, Pachyglossa, Plectoglossa, Pseudolingula.
7. Lingulella, Obolus, Pachyglossa, Palaeoglossa.
8. Ectenoglossa, Lingulella, Obolus, Plectoglossa.
9. Acanthambonia, Dictyonites, Glossella, Lingulella, Obolus, Palaeoglossa, Torynelasma.
10. Dictyonites, Eoconulus, Lingulella, Palaeoglossa.
11. Glossella, Lingulella, Obolus, Pachyglossa, Schizotreta, Spinilingula, Trematis, Westonia.
12. Leptobolus, Lingulasma.
13. Glossella, Glyptoglossa, Lingulasma, Obolellina, Orbiculoidea, Schizambon.
14. Schizambon, Siphonotreta.
15. Schizambon.
16. Conotreta, Spondylotreta.
17. Ehippelasma, Conotreta.
18. Acanthambonia, Conotreta, Paterula, Rhysotreta, Scaphelasma, Spondylotreta, Torynelasma, Undiferina.
19. Schizocrania, Schizotreta, Trematis.
20. Orbiculoidea, Schizotreta.
21. Schizambon, Schizotreta.
22. Acrotreta, Craniops, Obolellina, Obolus, Petrocrania, Philhedra, Schizambon, Schizotreta.
23. Elliptoglossa, Lingulops.
24. Elliptoglossa, Obolellina, Paterula, Pseudobolus.
25. Acanthocrania, Petrocrania.
26. Acanthocrania, Petrocrania, Philhedra.
27. Acanthocrania, Pachyglossa, Petrocrania, Schizotreta, Trematis.
28. Acrotreta, Conotreta, Lingulella, Pachyglossa, Schizotreta, Torynelasma.
29. Orthidiella, Trematorthis.
30. Orthidiella, Orthidium.
31. Archaeorthis, Orthidium, Pleurorthis.
32. Cyrtonotella, Hesperorthis, Pleurorthis, Rhysostrophia.
- 33-36. Orthambonites.
37. Mimella, Onniella, Orthambonites.
38. Nothorthis, Orthambonites, Taphrorthis.
39. Cyrtonotella, Nicolella, Taphrorthis.
40. Cyrtonotella, Taphrorthis.
41. Cyrtonotella.
42. Nicolella, Orthambonites, Ptychopleurella.
43. Glyptorthis, Ptychopleurella.
- 44-47. Glyptorthis.
48. Eridorthis, Glyptorthis.
49. Glyptorthis, Hesperorthis, Orthambonites, Productorthis, Ptychopleurella, Taphrorthis.

50. *Atelelasma*, *Cyrtonotella*, *Desmorthis*, *Eremotoechia*, *Glyptorthis*, *Hesperorthis*, *Ptychopleurella*.
- 51-54. *Hesperorthis*.
55. *Scaphorthis*.
56. *Multicostella*, *Productorthis*.
- 57-59. *Dinorthis*.
60. *Multicostella*.
61. *Chaulistomella*, *Dinorthis*, *Multicostella*.
62. *Multicostella*.
- 63, 64. *Chaulistomella*, *Multicostella*.
65. *Chaulistomella*, *Dinorthis*.
- 66, 67. *Chaulistomella*.
68. *Campylorthis*, *Chaulistomella*, *Multicostella*.
69. *Campylorthis*, *Chaulistomella*.
70. *Chaulistomella*, *Valcourea*.
71. *Camerella*, *Chaulistomella*, *Dinorthis*, *Multicostella*, *Plectorthis*, *Valcourea*.
72. *Chaulistomella*, *Dinorthis*, *Valcourea*.
- 73-75. *Valcourea*.
76. *Chaulistomella*, *Valcourea*.
77. *Eremotoechia*, *Tritoechia*.
78. *Anomalorthis*, *Atelelasma*, *Eremotoechia*.
79. *Atelelasma*.
80. *Atelelasma*, *Kullervo*.
81. *Atelelasma*, *Plectorthis*.
82. *Atelelasma*, *Cyrtonotella*, *Hesperorthis*, *Orthambonites*, *Pionodema*, *Productorthis*, *Ptychopleurella*.
83. *Desmorthis*, *Plectorthis*.
84. *Plectorthis*.
- 85-91. *Mimella*.
92. *Doleroides*, *Mimella*, *Plectorthis*, *Skenidioides*.
- 93-96. *Doleroides*.
- 97, 98. *Skenidioides*.
99. *Ancistrorhyncha*, *Elasmothyris*, *Eremotoechia*, Genus and species undet., *Kullervo*, *Mimella*, *Onychoplectia*, *Oxoplectia*, *Skenidioides*, *Tropidothyris*.
100. *Onychoplectia*, *Oxoplectia*, *Triplexia*.
- 101-105. *Oxoplectia*.
106. *Camerella*, *Oxoplectia*, *Parastrophina*, *Porambonites*.
107. *Porambonites*, *Salonia*.
108. *Camerella*, *Glyptorthis*, *Idiospira*, *Oxoplectia*, *Perimecocoelia*, *Porambonites*, *Taphrorthis*.
109. *Camerella*, *Idiostrophia*, *Rhysostrophia*.
110. *Camerella*, *Liricamera*.
111. *Camerella*, *Perimecocoelia*, *Stenocamara*.
112. *Camerella*, *Rhysostrophia*.
113. *Camerella*, *Idiostrophia*.
114. *Camerella*, *Perimecocoelia*.
115. *Camerella*, *Parallelasma*, *Stenocamara*.
116. *Camerella*.
117. *Camerella*, *Parastrophina*, *Perimecocoelia*.
118. *Brevicamera*, *Camerella*, *Parallelasma*, *Parastrophina*.
119. *Brevicamera*, *Parallelasma*, *Parastrophina*, *Perimecocoelia*, *Protozyga*, *Stenocamara*.
120. *Didymelasma*, *Neostrophia*.
121. *Camerella*, *Dalmanella*, *Hesperonomiella*, *Macrocoelia*, *Onychoplectia*, *Parallelasma*, *Triplexia*.
122. *Liricamera*, *Plectocamara*.

123. Plectocamara.
124. Dorytreta, Oligorhynchia, Rostricellula, Sphenotreta.
125. Oligorhynchia.
126. Ancistrorhyncha, Atelelasma, Chaulistomella, Dalmanella, Oligorhynchia, Phragmorthis, Plectocamara.
127. Ancistrorhyncha, Oligorhynchia.
128. Ancistrorhyncha, Drepanorhyncha, Mimella, Orthorhynchula, Rhynchotrema.
129. Ancistrorhyncha, Rostricellula.
130. Lepidocyclus, Rhynchotrema, Rostricellula.
- 131-137. Rostricellula.
138. Oxoplecia, Plectocamara, Rhynchotrema, Rostricellula.
139. Rostricellula.
140. Idiospira, Protozyga.
141. Cyclospira, Protozyga, Zygospira.
142. Cyclospira, Hallina, Protozyga, Zygospira.
143. Cyclospira, Fascifera, Hallina, Laticrura, Protozyga, Sphenotreta, Zygospira.
144. Laticrura.
145. Hirnantia, Howellites, Laticrura.
146. Cyclomyonia, Dalmanella, Diorthelasma, Eremotrema, Laticrura, Paurorthis, Phragmorthis.
147. Reuschella.
148. Genus and species undet., Phragmorthis, Reuschella.
149. Fascifera, Laticrura, Paurorthis.
- 150, 151. Paurorthis.
- 152, 153. Fascifera.
154. Pionodema.
155. Fascifera, Paurorthis, Pionodema.
156. Pionodema.
157. Cristiferina, Dalmanella, Onniella, Paucicrura, Pionodema.
158. Cristiferina, Dalmanella.
159. Cristiferina, Onniella, Paucicrura.
160. Cristiferina, Eremotrema, Paucicrura.
161. Cristiferina, Dalmanella, Onniella.
162. Dalmanella, Paurorthis, Pionodema.
163. Aporthophyla, Eichwaldia, Ingria.
164. Aporthophyla, Toquimia.
165. Taphrodonta.
166. Apatomorpha.
167. Palaeostrophomena.
168. Glyptambonites, Palaeostrophomena.
169. Isophragma, Palaeostrophomena, Sowerbyites.
170. Isophragma.
171. Glyptambonites, Isophragma.
172. Hesperonomiella, Paucicostella, Ptychoglyptus, Taffia.
173. Glyptambonites, Limbimurina, Macrocoelia, Paucicostella, Ptychoglyptus, Strophomena.
174. Ptychoglyptus.
175. Glyptambonites.
176. Glyptambonites, Palaeostrophomena.
- 177, 178. Titanambonites.
- 179-181. Sowerbyites, Titanambonites.
- 182, 183. Sowerbyites.
184. Bimuria, Eoplectodonta, Isophragma, Palaeostrophomena, Sowerbyites, Titanambonites.
185. Hesperomena, Syndielasma, Titanambonites.

186. Ancistrohyncha, Dactylogonia, Eremotoechia, Leptellina, Ptychoglyptus, Reuschella, Zygospira.
187. Leptellina.
188. Leptellina, Leptelloidea.
- 189-191. Leptellina.
192. Bilobia, Eoplectodonta.
193. Anisopleurella, Bilobia.
194. Bilobia, Bimuria, Dactylogonia, Palaeostrophomena, Titanambonites.
195. Anisopleurella, Bilobia, Idiospira, Leptellina, Toquimia, Xenambonites.
- 196-202. Sowerbyella.
203. Eoplectodonta, Sowerbyella.
- 204, 205. Sowerbyella.
206. Sowerbyella, Titanambonites.
207. Eoplectodonta.
208. Eoplectodonta, Leptaena.
209. Eoplectodonta, Goniotrema, Sowerbyites.
210. Bimuria, Christiania, Isophragma.
211. Bimuria.
212. Bimuria, Leptaena.
213. Craspedelia, Hesperinia, Isophragma, Ptychoglyptus Rhipidomena, Strophomena.
214. Christiania.
215. Chonetoidea, Christiania, Sowerbyella.
216. Dactylogonia.
217. Dactylogonia, Murinella, genus and species undet.
218. Dactylogonia, Rhipidomena.
219. Dactylogonia, Leptellina.
220. Dactylogonia, Limbimurina.
221. Bellimurina, Christiania, Laticrura, Limbimurina, Petroria, Phragmorthis.
222. Bellimurina, Limbimurina, Strophomena.
223. Bellimurina, Cyphomena, Limbimurina, Murinella, Pelonomia.
224. Cyphomena.
225. Dactylogonia, Teratelasma.
226. Dactylogonia, Murinella.
227. Murinella.
228. Cyphomena, Dactylogonia, Leptaena, Murinella.
229. Furcitella, Hesperinia, Høltedahlinea.
230. Macrocoelia, Platymena.
231. Glyptomena, Macrocoelia.
- 232-234. Macrocoelia.
235. Glyptomena, Macrocoelia.
236. Macrocoelia, Öpikina.
- 237, 238. Öpikina.
239. Macrocoelia, Öpikina.
- 240-244. Öpikina.
245. Glyptomena, Öpikina.
246. Glyptomena, Öpikina, Pionomena.
247. Macrocoelia, Öpikina, Rafinesquina.
248. Pionomena, Rhipidomena, Strophomena.
249. Macrocoelia, Öpikina, Rhipidomena.
- 250-253. Rhipidomena.
254. Rhipidomena, Strophomena.
- 255-262. Strophomena.
263. Strophomena, Trigrammaria.

- 264. Strophomena.
- 265. Furcitella, Pionomena, Strophomena.
- 266. Platymena, Rafinesquina.
- 267. Colaptomena.
- 268. Dinorthis, Fascifera, Oligorhynchia, Öpikina, Plectocamara, Ptychoglyptus, Sowerbyella, Stenocamara, Xenambonites, Zygospira.
- 269. Eoplectodonta, Hesperorthis, Paurorthis, Plectorthis, Reuschella, Sowerbyella.

FIGURES

| | Page |
|---|------|
| 1. Map showing location of sections in the Appalachians..... | 37 |
| 2. Diagram illustrating facies changes in East Tennessee and southwest Virginia from north to south. The diagram is not made to scale because of difficulties in drawing the facies shifts in the rapidly thickening wedge south of Friendsville..... | 40 |
| 3. The same facies pattern with formation names..... | 40 |

CHART

| | |
|---|-----|
| 1. Chart showing correlation of formations and members from which brachiopods are mentioned, described, or illustrated..... | 130 |
|---|-----|

Charles D. and Mary Vaux Walcott Research Fund

CHAZYAN AND RELATED BRACHIOPODS:
PART I, TEXT

By G. ARTHUR COOPER

*Curator of Invertebrate Paleontology and Paleobotany
United States National Museum*

(WITH 269 PLATES IN PART II)

Section I. THE FORMATIONS

INTRODUCTION AND STRATIGRAPHIC SETTING

The brachiopods forming the subject of this monograph are a natural sequel to those of the Ozarkian and Canadian periods. While Dr. E. O. Ulrich and I were preparing the monograph on Ozarkian and Canadian brachiopods it became evident that post-Canadian brachiopods were as little known as those on which we were working. It was, therefore, planned to prepare a second monograph under the joint authorship of Ulrich and myself on the brachiopods of Ulrich's Chazyan which included all the rocks between the top of the Canadian and the Lowville. Ulrich's division comprised a very imposing sequence of rocks in the Appalachians and many other parts of North America. To his Chazyan was added the Black River group of rocks and its correlates as Ulrich understood this group. The brachiopods from the Black River were clearly closely related to those of the Chazyan and, like the Chazyan, were little known. The plan was to regard the lower Trenton, as understood by Ulrich, as the upper limit for the study.

Many unforeseen circumstances transpired to delay the work, and in the meantime Dr. Ulrich's health declined to such an extent that he withdrew from the project.

While the studies were progressing and the collections were being brought together, views were changing on the stratigraphy of the Chazyan and Black River divisions. G. M. Kay, in New York and Ontario, was revising the Trenton and elaborating the Rockland division which proved to be of wide distribution. At the same time, Byron N. Cooper, then of the Virginia Geological Survey, and C. E. Prouty, of the Tennessee Valley Authority, were establishing in Tazewell County, Va., a detailed section that was to become a standard for the area. These studies and my own investigations in the Appalachians showed clearly that the Chazyan of Ulrich actually included rocks from Chazyan to Trenton and that the Black River of Ulrich was in large part Trenton age. In spite of these disclosures it seems unnecessary to change the name of this monograph. The formations now have a far different alignment from that which Ul-

rich gave them, but the brachiopods include Chazy forms with related Black River and Trenton types.

BACKGROUND FOR THE STUDIES

In 1939, I had my first introduction to the Appalachians with Dr. Charles Butts and Dr. Josiah Bridge. Dr. Butts, who knew the Appalachians more intimately than anyone before him, kindly consented to show Bridge and myself their intricacies from Pratt Ferry in Alabama, where the Appalachian structures plunge under the Coastal Plain, to Winchester, Va. We saw the facies changes involving the Athens and Arline formations and the reefs of the Effna at Porterfield Quarry. This first expedition was followed by others, many of them with Dr. B. N. Cooper.

My association with Dr. B. N. Cooper began about 1941 when the latter called at the National Museum to confer regarding some of his fossils from Virginia. Cooper was then studying the Ordovician sequences to learn of deposits of chemical limestone. These studies had made him familiar with many interesting and important sections. The conference resulted in the discovery that the two of us independently had arrived at the same facies picture for the Middle Ordovician stratigraphy in the Appalachians of Virginia. It was then decided to join forces and apply the new ideas to the sequences southwest of Virginia in Tennessee, Georgia, and Alabama. We made seven expeditions between 1941 and 1951.

Additional background was obtained in several expeditions to the Arbuckle Mountains, and two expeditions to the Antelope Valley of Nevada where an incomparable Ordovician sequence is exposed. Dr. Bridge and I visited Chazy in 1938 to study the typical sequences along Lake Champlain. Alwyn Williams of Wales and I examined numerous sections in central Pennsylvania, covering the ground described by G. M. Kay. The same party examined sections in southern Wisconsin, Minnesota, and Iowa. All these expeditions added to our knowledge and increased the collections.

BUILDING THE COLLECTION

The collection on which this study is based is a large one and was derived from many sources. The initial stages of building consisted of selecting good specimens from the large mass of stratigraphic material obtained by various members of the U. S. Geological Survey. Part of this material was collected by E. O. Ulrich, and another large part was brought in by Charles Butts during his years of mapping in the Appalachians. Other contributors were R. S. Bassler, G. W. Stose, Josiah Bridge, and Edwin Kirk.

The largest part of the collection was obtained by me in various trips to the Appalachians and the West. Each year specific localities of promise were visited and revisited and rare fossils tracked down so that adequate material for description was finally brought together. It was mainly through my efforts that much silicified material was brought in, and later processed. It was this material

that produced so many of the small and unusual fossils such as those from Pratt Ferry, Porterfield Quarry, and Friendsville.

Gifts to the Museum.—I am grateful to many of my colleagues for gifts of important material:

Dr. G. M. Kay, Columbia University, presented specimens from Ontario and New York; Dr. B. N. Cooper presented a fairly large collection from the Appalachian Valley in Virginia; Dr. C. E. Decker presented to Dr. Ulrich an extensive suite of collections from the Arbuckle Mountains; O. C. Cole, of Kenyon, Minn., gave the Museum many brachiopods from the Ion and Prosser formations of Minnesota; Dr. G. Winston Sinclair presented several collections, one from Paquette Rapids, Ontario, another from the vicinity of Montreal, and an interesting lot of *Strophomenas* from Quebec and Ontario; Dr. Robert R. Shrock presented an extensive suite of specimens from the cryptovolcanic structure in Kentland, Ind.; Dr. Helgi Johnson, of Rutgers University, and Dr. Cecil Kindle, of City College of New York, gave small but choice collections of Table Head material from Newfoundland; Dr. C. W. Merriam presented the Museum with an extensive collection of early Middle Ordovician fossils from the Antelope Valley of Nevada; Dr. Lawrence D. Whitcomb presented specimens of the new genus *Limbimurina* from Pennsylvania; Dr. L. F. Hintze presented a few specimens from the Confusion Range, Utah; Ray C. Gilbert made a present of a few exceptional specimens from the lower part of the section near Lusters Gate, Blacksburg, Va.; Dr. Robert B. Neuman presented a collection from the Row Park and New Market formations in Maryland and Pennsylvania; a superb lot of fossils from the Arbuckles sequence was donated by Dr. A. R. Loeblich, Jr., now of the U. S. National Museum staff.

Borrowed material.—Early in the work on this monograph the officials of the Carnegie Museum lent the large and valuable collection of Chazy brachiopods accumulated by the late Dr. P. E. Raymond, who made pioneer studies on this group of rocks and its brachiopods. Peabody Museum, through Dr. C. O. Dunbar, lent material from the Mingan Islands. Dr. G. M. Kay, Columbia University, lent a few rare specimens from New York and Ontario.

PREPARING THE FOSSILS

The collection on which this monograph is based consists of many superb specimens. The material was prepared by several methods. Throughout the United States and Canada fossils frequently occur in a silicified state. In the Appalachians, many localities exist where the fossils can be removed from the rock by means of hydrochloric and acetic acids. Indeed, in some localities such as the Cahaba Valley, Ala., and the region around Friendsville, Tenn., fossils abound in the residual soil resulting from the deep weathering of the Little Oak and Arline limestone. In these places the silicification is often somewhat coarse in texture but is, nevertheless, very good.

Muddy limestones frequently yield good silicified specimens. In etching such material, great patience is required because decalcification of the rock yields a mass of mud, often fairly hard, from which the fossils must be taken. It requires

considerable care to pick or wash the mud from delicate and brittle interiors. The Lincolnshire limestone, such as that at Shiloh Church on the north side of Clinch Mountain in the Pressmens Home (T.V.A.) Quadrangle, commonly produces quantities of mud when decalcified, and the shells are brittle and sometimes fractured. They are nevertheless of the finest quality but require great care in handling.

Recognition of silicified brachiopods is generally not difficult because the specimens are usually weathered into relief on surfaces. The shells, too, often show silicious rings or the blue-gray color of chalcedony. When selecting material for etching, it is a good plan to look for blocks or take pieces of ledge rock showing specimens well scattered throughout the mass and on all sides of the block.

Inarticulate brachiopods may be prepared by dissolving limestone in acetic acid. This is a method described by W. C. Bell (1948). Generally, inarticulates are not sufficiently common to give an abundance of specimens from limestone pieces. The locality at Pratt Ferry, Ala., is unique in furnishing a great variety of inarticulates. Some inarticulates have been prepared by using dilute hydrochloric acid. This is true of much of the cobbly limestone material occurring in the lower part of the Edinburg limestone. *Paterula*, *Elliptoglossa*, *Conotreta*, occasional linguloids, and *Schizambon* have been removed from this part of the column by hydrochloric acid as well as acetic acid.

Chemical means can also be used to prepare molds of the interior and exterior of brachiopods. This can be successfully accomplished on specimens that are not silicified and that are preserved in a silty or fine sandy matrix. It is best to apply the acid with a brush or medicine dropper so that the solution of the shell can be controlled. It is usually necessary to harden the newly exposed matrix and also newly revealed parts so that the mold will not be injured. Numerous specimens from the Oranda formation were prepared by this treatment.

Most of the interiors of unsilicified specimens were prepared with needles ground to a chisel edge. An excellent utility point may be made by beveling a needle of appropriate gage at various angles to the long axis, depending on the work to be done. This beveling produces a broad face with sharp edges for scraping and also a sharp point for digging. It is best to scrape away matrix against the shell rather than dig it away. Careful scraping leaves no unsightly scratches.

A number of interiors were prepared by roasting the specimens in a blast lamp and then letting the shell cool. This treatment calcines and softens the shell to such an extent that it can be scraped away by a beveled needle. The shell generally turns white from the heating and makes a convenient color contrast with the matrix. Careful scraping will produce molds of the interior that are quite as good as those obtained by dissolving the shell away. The success of a brachiopod study depends almost entirely on the information derived from the interior; consequently, no pains should be spared to preserve this part.

ACKNOWLEDGMENTS

Many friends and interested persons have been of great assistance in the preparation of this monograph. Inasmuch as the work originated as a joint un-

dertaking by a member of the U. S. Geological Survey and one from the U. S. National Museum, I have enjoyed favors from many of my colleagues in both organizations. Dr. Alexander Wetmore, former Secretary of the Smithsonian Institution, made possible my numerous field expeditions which furnished the major part of the collection. The studies were supported by Dr. R. S. Bassler, the head curator of the department of geology in the National Museum. My colleague, Dr. A. R. Loeblich, Jr., helped immeasurably as field companion and donor of a large and exceptionally fine collection of Simpson brachiopods.

Dr. J. B. Reeside, then chief of the section of stratigraphy and paleontology, made it possible for me to have and use parts of the collections of the U. S. Geological Survey made by Dr. E. O. Ulrich and Dr. Charles Butts. Drs. T. B. Nolan and Harry S. Ladd assisted in field trips to the Southwest and West by allowing the use of Survey equipment.

The early stages of the work were greatly facilitated by a grant from the Geological Society of America through the Penrose Fund. This grant was made in 1937 to help me in organizing, preparing, and photographing specimens. Dr. Preston E. Cloud, Jr., now chief of the paleontology and stratigraphy branch of the Geological Survey, who was the recipient of the grant, prepared and photographed most of the materials studied prior to 1938. I wish to express my thanks for this grant and my appreciation of the diligence of the grantee.

In making acknowledgments, I cannot overlook the contributions of my two mentors in Ordovician stratigraphy, now deceased. It was originally planned that this should be a joint undertaking with Dr. Ulrich, but because of the long delay in getting under way Dr. Ulrich voluntarily retired from the project. Nevertheless, I will always remember the hours of instruction received from him. To Dr. Charles Butts I owe much for his inspired guidance in the Appalachians. Dr. Butts knew Appalachian stratigraphy as no one before him, and he led me and my colleagues to many places where collections could be made and information obtained. I am also grateful to Dr. Butts for the many discussions, often heated but always illuminating, on problems of Appalachian stratigraphy. Dr. Edwin Kirk, of the U. S. Geological Survey, helped with information on sections in Nevada.

Many friends outside of Washington helped me in the laboratory and field. Dr. G. M. Kay furnished information on many localities. Dr. William E. Ham, Oklahoma Geological Survey, spent several days in the Arbuckles with me; Dr. C. W. Wilson, Vanderbilt University, spent several days in the field and furnished important information from his wide knowledge of the Central Basin of Tennessee. Thanks are due the late Dr. Percy E. Raymond, of Harvard College, for making it possible for me to study the type specimens of Southern Appalachian brachiopods described by him and Dr. Bradford Willard. Similar acknowledgments are due to Dr. E. M. Kindle and Miss Alice Wilson, both former officials of the Canadian Geological Survey. They kindly placed at my disposal type specimens of many of Elkanah Billings' species for study and photographing while I was in Ottawa in 1938. Thanks are extended to Dr. W. A. Bell, Canadian Geological Survey, for permission to prepare the interior of one of the types of the brachiopod *Petroria* figured on plate 22I, E. Dr. C. W. Mer-

riam, U. S. Geological Survey, furnished much information on stratigraphy in Nevada.

Thanks are extended to two companions of several field expeditions, Dr. Byron N. Cooper and Dr. Raymond S. Edmundson, both former members of the Virginia Geological Survey. These expeditions with Dr. Cooper and our association during the 6 months he spent at the National Museum were informative and inspiring.

Dr. Raymond S. Edmundson, now of the University of Virginia, and a colleague of Dr. B. N. Cooper in the mapping of the Virginia chemical limestones, accompanied us on several expeditions. His brilliant and careful structural and stratigraphic work was of valuable assistance; he helped lay the groundwork of the stratigraphy.

LOCATION OF TYPES AND ABBREVIATIONS

Most of the types illustrated in this monograph belong to the U. S. National Museum. It was desirable to illustrate specimens borrowed from other institutions to show structures or species not exhibited in National Museum specimens or present in the National Collection. All the type repositories are designated herein, as follows:

- A.M.N.H. American Museum of Natural History.
- Carnegie Mus. Carnegie Museum.
- Columbia Univ. Columbia University.
- G.S.C. Geological Survey of Canada.
- M.C.Z. Museum of Comparative Zoology, Harvard College.
- U.S.N.M. United States National Museum.
- Y.P.M. Peabody Museum, Yale University.

In the descriptive part of the monograph all numbers are those of the National Museum unless otherwise designated. In some cases, U.S.N.M. is prefixed to numbers where ambiguity might otherwise appear.

In lists, names marked by an asterisk are doubtful identifications.

NOTES ON THE CORRELATION CHART

Any chart depicting correlation of formations is really only a report of progress that approximates but never portrays the real truth. The chart presented herewith (chart 1, facing p. 130) is certainly not a final picture of this part of the Ordovician. Many parts of it are not in clear focus and it will take much study and more collecting of fossils to eliminate these fuzzy portions. Throughout all the Ordovician covered by this chart, much paleontological work still needs to be done. One of the important weaknesses in our knowledge of brachiopods is the small amount of information that has been gleaned on this group from the Table Head series of Newfoundland. The correlative rocks in Nevada are also in need of attention. With the appearance of this monograph the Appalachians will be better known, but many parts of them have not been studied and still remain virtually unknown.

Another quality of the correlations recorded herein must be stated to the reader so that he can better understand the difficulties involved. Correlations based on a single group of animals seldom if ever give the true story of relationships and correlation of strata. Correlation by complete faunas is the only sound method because different parts of a fauna may be retarded or advanced and only the sum total gives the truth. The present chart is based mostly on evidence deduced from a study of brachiopods, and most of the relationships herein depicted were detected by comparison of brachiopod faunules. However, when Dr. B. N. Cooper was making his studies of the trilobites of these same rocks at the National Museum in 1946, we were in close touch. Correlation by trilobites closely parallels that based on the brachiopods. A careful check by bryozoans, which are very numerous in the Appalachians and elsewhere, is a natural sequel to the present studies.

In preparing the chart I did not completely overlook the value of other fossils, but, on the other hand, I was well aware of the unreliability of some "guide fossils." Reference is made to *Cryptophragmus antiquatus*, *Tetradium cellulosum*, and *Maclurites "magnus."* *Cryptophragmus* is now known to have a long range and thus not to be an absolute indication of the Lowville or Pamela as hitherto believed. *T. cellulosum* is known from Trenton rocks as well as Lowville. *Maclurites* is long-ranged and is not an infallible guide to the Chazy, as confusion in Pennsylvania between Lemont and Hostler shows.

The chart contains five new stage terms which are designed to divide this part of the Ordovician into related parts. These stage terms are here proposed by myself and B. N. Cooper. Older stage terms, such as Chazyan and Black River, are no longer of use because these have been so defined that they do not describe the stratigraphy, or, as in the case of the Black River, the interval represents only a part of what we regard as a natural grouping of faunas. Grabau's (1909) usage of Chazyan included the Black River, which we regard as more closely related to the overlying Rockland than to the Chazy group below. The Ulrich (1911) conception of the Chazyan was for the interval between the Lowville and the top of the Canadian (Beekmantown or Knox dolomite), which is far too inclusive. The name Bolarian (Kay, 1948, p. 1402) includes two divisions; Hatterian and Hunterian, but these, too, are unsatisfactory to show the relationships as B. N. Cooper and I understand them. The Hatter formation, whose time designation is Hatterian, appears to be the same as Hunterian if, as shown in this monograph, the Hatter is equivalent to Ridley. The Hunterian includes Lowville, Chaumont, and their equivalents, but besides them Kay adds the Witten formation. The Witten, with its *Pionodema* and *Doleroides*, is placed by B. N. Cooper and myself as a correlative of the Rockland. Furthermore, the Rockland fauna is closely tied to that of the Chaumont, as I understand those fossils. Thus Bolarian is unsuited to depict the stratigraphic situation as understood herein.

It was not a simple task to find satisfactory names for the stage terms here offered, but the sequences named are well exposed in the vicinity of the geographic locale selected.

Whiterock stage.—This name is taken from Whiterock Canyon in the Monitor

Range in the south center of the Roberts Mountains (1°) Quadrangle, Nev. The rocks of the interval are well exposed in parts of the Antelope, Monitor, and Toquima Ranges shown on the same sheet. The brachiopod fauna taken from rocks deposited during this stage is characterized by numerous orthids, the early strophomenids, plectambonitids, and the decline of the Syntrophiacea. Correlative rocks appear in the Arbuckle Mountains of Oklahoma and the Table Head series of Newfoundland. Exotic blocks containing fossils related to the Table Head of Newfoundland have been found in the boulders of the Mystic conglomerate and from a little-known formation near North Cambridge, N. Y. Equivalents of these beds in Europe are not clearly understood, but some related forms have been taken in Norway and Estonia.

Marmor stage.—The name for this stage is taken from the point called Marmor, just northeast of Friendsville on the Concord (T.V.A. 138-SW) Quadrangle, Tenn. The reference section is along the railroad to the east of Marmor and extends to the adjacent Louisville (T.V.A. 138-SE) Quadrangle. This stage includes the Chazy group of rocks and its correlatives.

Ashby stage.—The name for this stage is taken from a road intersection on Hogskin Creek, in the northeast quarter of the center subquad. of the Maynardville (30') Quadrangle, Tenn. In the Hogskin Valley the formations Elway and Lincolnshire comprise this stage and are well exposed. In fact part of the Lincolnshire and its shaly Hogskin member are especially well displayed. Kay (1948, p. 1402) places the formations of this stage in his Chazyan, but I believe that this is not justified on paleontological grounds. The Elway-Lincolnshire contains many Chazy elements, but it also contains brachiopods, such as the coarse-ribbed dinorthids, which are unknown in the Valcour or any other part of the Chazy group. It is believed that the rocks deposited in the Ashby stage are younger than those of the Marmor (Chazy group).

Porterfield stage.—This name is taken from the Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle, Va., and its environs. This stage is characterized by the prolific and exotic fauna that floods into the Appalachians and blots out and absorbs the Lincolnshire fauna. The Porterfield fauna is strongly linked to the Stinchar-Balclatchie fauna of the Girvan of Scotland. It is characterized by *Christiania*, *Palaeostrophomena*, *Isophragma*, and a host of other restricted genera. In the vicinity of the type area the sequence of rocks deposited during this time is not thick, but to the east the section becomes enormously thick. The fauna dies out in the upper part of the Benbolt and is replaced in the Wardell by familiar "Black River" types. In northern Virginia the Porterfield fauna occupies most of the Edinburg formation and, in modified form, characterizes the Oranda formation.

Wilderness stage.—This stage takes its name from the Wilderness Trail (U. S. Highway 58) that parallels the bold Cumberland Front in western Virginia. Rocks deposited at this time are well exposed for several miles east of Cumberland Gap and are revealed in their entirety along the railroad at the switch near Hagan, Rose Hill (T.V.A. 161-NE) Quadrangle. This stage includes the old Black River plus the Rockland and their equivalents. The fauna is especially

characterized by abundance of *Öpikina*, *Strophomena*, *Pionodema*, and *Doleroides*. It is succeeded by the Trenton with its flood of cryptolithid trilobites and more modern brachiopods, many of which appear in the preceding stage but fail to make a prominent impress on the fauna. The Oranda fauna is believed to have lived in Wilderness time and represents the fading stages of the Porterfield fauna, which lingered on in eastern areas probably now obliterated by the intrusions of the Blue Ridge and Great Smokies and the metamorphism of sediments now underlying the Piedmont.

Trenton stage.—This stage is modified by removal of the Rockland which has mostly fossils derived from the underlying Black River and Witten. Deposition of the Sherman Fall is thought to inaugurate the Trenton stage.

The chart also gives the range of the important genera described. A star indicates that the genus appears as far as known at present, at the point where the star appears, and then ranges to a point beyond the upper limits of the chart. An asterisk behind a generic name or group of names means that the genera do not range beyond the point where the asterisk occurs. A number of genera so marked are confined to the Pratt Ferry formation. Numbers are placed at the top and bottom of the chart to make the finding of the generic name in any column easier. In the annotated list of genera and species appearing in Section II each genus bears the number of the column in which it appears.

GEOGRAPHIC AND GEOLOGIC SETTING OF THE FORMATIONS

In the following pages are set forth brief descriptions of the formations from which were taken the brachiopods forming the subject of this report. The geographic setting for the formations is given according to the region or realm in which they are developed. In the Southern Appalachians the stratigraphy is so complicated and the formations so numerous that it seemed advisable to arrange the formations alphabetically and reserve the regional discussion for the companion paper to the present volume being prepared by B. N. Cooper and myself. That discussion will consider all the Southern Appalachian formations from Pennsylvania to Alabama in detail. Most of that information need not be given here, but for the sake of completeness the formations and their faunas are described and listed.

My field work has not been sufficiently extensive to cover all the regions from which Chazyan and related brachiopods have been taken. Some of the discussion is therefore based on the literature. This is true also of the fossil lists. I have not seen all the species listed under some of the formations, nor does the National Museum have collections from all the formations, but the names are recorded nevertheless.

In discussing the formations, it seemed unnecessary to repeat any material already appearing in the "Lexicon of Geologic Names" (Wilmarth, 1938). This useful work contains the definitions of all formations described in the United States up to January 1, 1936. Formations named after that time are herein described more fully. Although the definitions in the "Lexicon" are complete and some information on correlation is given, the book contains scarcely any

paleontological information. Inasmuch as the present work is concerned wholly with brachiopods, stratigraphic discussion and correlation are based almost wholly on them. The bearing on correlation of fossils other than brachiopods is mentioned only in instances in which brachiopods tell an inaccurate or equivocal story.

The lists of brachiopods appearing under the formation names have been obtained from the studies recorded herein and from lists published by other authors. In some instances listed identifications are so fantastic that the writer has placed an asterisk before the name to show that the identification is incorrect. For example, some Richmond species have been identified in the Simpson group. In many instances, however, I have not seen specimens recorded for all the formations and can only let the names stand even though considerable suspicion of incorrectness may attach to the identification. This naturally detracts from the value of the lists, but in any study of paleontological literature it must be realized that listed forms must be used with great care. This is especially true of the lists presented by the nonspecialist stratigrapher, who still feels that he can identify any fossil.

In spite of the deficiencies noted above, the lists do contain the names of all species I have identified or described. These also appear in a master list at the head of the section on the brachiopods, but it will not be possible to check the species appearing in the stratigraphical section with those in the brachiopod part because the master list contains only species considered in the text.

The formation lists are notably incomplete in some instances. All the formations have not been evenly collected, and the need for some formation names became apparent only at a late stage of the work. Consequently, lists for the Sequatchie Valley formations, for example, are not entirely satisfactory, and the same situation exists with most of the marbles. Specimens from the marbles are usually difficult to identify because of exfoliation of shell, lack of preservation of muscle scars, and generally poor interior preservation; consequently, the age of the marbles was obtained by blocking them in between well-studied beds above and below. Furthermore, the faunas of the marbles are very much the same in generic composition, a remarkable example of facies restriction, which makes the identification of an isolated marble a difficult proposition. At present the marbles cannot be taken out of their sequences and satisfactorily identified or their age determined. They must some day be studied individually.

Most of the lists suffer from incompleteness. This study has taken a long time and a huge collection was examined. Nevertheless, the collection on which it is based represents only a minute fraction of the fossils that must be collected and studied in the future to determine the true story of Ordovician stratigraphy and paleontology. It is at best a good beginning.

The brachiopods discussed in this monograph come from the following regions:

Newfoundland.

The St. Lawrence and Ottawa Valleys and adjacent areas.

The Champlain, Mohawk and Hudson Valleys.

The Appalachians (Pennsylvania to Alabama).

The Central Basin of Tennessee, Wells Creek Basin and High Bridge, Kentucky.
 The disturbed area at Kentland, Indiana.
 The Mississippi Valley.
 Arbuckle and Wichita Mountains, Oklahoma.
 The Black Hills, South Dakota.
 The Great Basin.
 Formations in Utah and California.

I. NEWFOUNDLAND

Along the west coast of Newfoundland fossiliferous Ordovician rocks are exposed at many places. These were examined by Logan (1863, p. 870) who separated them into four divisions, lettered K-N. According to Schuchert and Dunbar (1934, pp. 63-69) these four divisions form a natural group for which they proposed the name "Table Head series."

TABLE HEAD SERIES

The lower Table Head (K, L) is composed mostly of limestone somewhat massively bedded in the lower part but the main mass consisting of thin-bedded limestone weathering to rubble, the sequence measuring 811 feet. Middle Table Head (M) consists of dark limestone and interbedded black shale, a total of 270 feet. The upper part of the series (N) is composed chiefly of black carbonaceous shale 300 feet thick.

Brachiopods occur in all parts of the sequence in more or less abundance. The following genera and species are known:

Acrotreta gemma Billings
Aporthophyla aurora (Billings)
Archaeorthis electra (Billings) = *A.* new species
Camerella parva Billings
C. tumida Cooper
Ectenoglossa nympha (Billings)
Ectenoglossa sp. 1
Idiostrophia perfecta Ulrich and Cooper
Idiostrophia plicata Cooper
Obolus cyane (Billings)
Obolus sp. 1
Onychoplectra kindlei Cooper
Onychoplectra sp. 1
Orthidium fimbriatum Cooper
Pelonomia delicatula (Billings)
Pleurorthis imbecilis (Billings)
Pleurorthis sp. 1, 2
Porambonites sp. 2
Ptychoglyptus ? *kindlei* Cooper
Rhysostrophia sp. 2

Correlation of Table Head series.—The facies of the Table Head series is that of a black shale and limestone environment and is strongly suggestive of the Liberty Hall facies of the Edinburg formation or the Whitesburg formation of Tennessee. The trilobites of the Table Head are similar to those from the

Virginia and Alabama formations with the exception that certain forms occurring in Newfoundland, such as the trilobite *Ectenonotus*, have never been seen in the Appalachians. The brachiopods apparently form a homeomorphous series when compared to those of the Appalachians. The small orthids, for example, prove to belong to *Archaeorthis*. *Hesperonomiella* seems to be present and numerous others not yet described that look like higher genera but when examined on the interior prove to have relationships to types that lived in late Canadian or in Whiterock time.

In the present paper I have included only the few Newfoundland species for which good material was at hand. Genera other than those here recorded are represented. For example, *Rhysostrophia* is a not uncommon genus, but the National Collections are not provided with good specimens.

The elements of the Table Head fauna are known elsewhere in Quebec, New York, and Nevada. In Quebec some of the boulders of the Mystic conglomerate, the youngest boulders yet found, contain many elements and even actual species of the Table Head of Newfoundland. A small *Rhysostrophia* suggestive of the Table Head one is present; *Pleurorthis* is common to both, as is *Ptychoglyptus* (?). Also common to Newfoundland and Quebec are *Idiostrophia* and *Orthidium*.

Genera common to the Table Head of Newfoundland and the upper Pogonip of Nevada are: *Idiostrophia*, *Orthidium*, *Rhysostrophia*, *Hesperonomiella*, *Aporthophyla* and *Porambonites* ?. The trilobite *Ectenonotus* is common to Nevada, Quebec, and Newfoundland.

LONG POINT SERIES

This name is applied to the 1,500 feet of section exposed at Long Point in southwestern Newfoundland with thin-bedded, greenish-gray, calcareous, rippled sandstones and siltstones and zones of greenish shale in the upper part; greenish-gray calcareous shale interbedded with limy sandstone and sandy limestone in the middle part; and thin-bedded sandy limestone with oolitic limestone and intraformational conglomerate and some heavier beds at the base. Brachiopods listed from the series are:

- Camerella* aff. *C. volborthi* Billings
- Dalmanella* *rogata* (Sardeson)
- Dinorthis* aff. *D. iphigenia* (Billings)
- Glyptorthis* *bellarugosa* (Conrad)
- G.* cf. *G. crispata* (McCoy)
- Hesperorthis* aff. *H. tricenaria* (Conrad)
- Rafinesquina* *alternata* (Conrad) = *R. trentonensis* (Conrad)
- R.* aff. *R. deltoidea* (Conrad)
- R.* aff. *R. minnesotensis* = *Öpikina*
- Sowerbyella* *sericea* ? (Sowerby)
- S.* aff. *S. undulata* (Salter)
- Triplisia* *extans* (Emmons)

**Valcourea* sp.

Correlation of Long Point series.—The listed fossils suggested a Trenton age for the Long Point series. *Glyptorthis bellarugosa*, *Rafinesquina trentonensis*, *Dinorthis* aff. *D. iphigenia*, and *Triplecia extans* are now regarded as good indicators of the Rockland formation or Upper Wilderness stage or possibly slightly higher in the Trenton. *Valcourea* sp. is the only brachiopod listed that is not in harmony with a Trenton age, but this one may not be correctly identified.

COW HEAD BRECCIA

The Long Point series is overlain by the Cow Head breccia of uncertain thickness, ranging from 350 feet to probably more than 1,200 feet. This formation consists of a mass of ragged blocks of enormous size and of several different ages. No fossils have been taken from the matrix of the breccia, consequently a definite age is not known. The blocks incorporated in the mass range in age from late Cambrian to those of the Long Point series. The formation is thus definitely younger than the Long Point.

HUMBER ARM SERIES

The Cow Head breccia is overlain by 2,700 feet of red, green, and black shales of the Humber Arm series. The few graptolites and brachiopods, among them *Paterula amii* Schuchert, found in the series are thought to be no younger than medial Ordovician. However, Schuchert and Dunbar (1934, p. 98) conclude that some late Ordovician may be present because of the enormous thickness of the series.

2. ST. LAWRENCE AND OTTAWA VALLEYS AND ADJACENT AREAS

Areas of Ordovician rock exposure, including the stratigraphic interval embraced by this study, appear in seven general areas: The Mingan Islands in the St. Lawrence River north of the west end of Anticosti Island; Quebec City; Montreal; along the Ottawa River in the vicinity of Ottawa and Hull; at the head of the St. Lawrence Valley in New York and adjacent Canada; the section at Coboconk, Ontario; and Manitoulin Island region on the north side of Lake Huron in Ontario.

MINGAN ISLANDS

These islands form a group in the St. Lawrence River just north of the west half of Anticosti Island. A sequence of Chazyan rocks called the "Mingan formation" has long been known on these islands.

Mingan formation.—The maximum thickness of this formation is 155 feet, according to Twenhofel (1938, p. 23) who described it in detail. The upper 116 feet are composed of limestone containing numerous fossils. Below these limestones occur 20 feet of shale with some beds of quartzite and lime sands. The basal 3 to 8 feet is composed of sandstone and conglomerate. Fossils occur in

all parts of the sequence. The brachiopods listed by Twenhofel and Whiting (1938), with additions by Cooper, are:

Ancistrorhyncha ? *vacua* Cooper

Camarella ? *longirostris* Billings = *Onychoplecia longirostris* (Billings)

Camarotoechia orientalis Billings = *Rostricellula orientalis* (Billings)

C. pristina Raymond = *Rostricellula pristina* (Raymond)

Dactylogonia extensa Cooper

Glyptorthis cf. *bellarugosa* (Conrad) = *Glyptorthis* sp.

Hesperorthis ignicula (Raymond)

Lingula huronensis minganensis Twenhofel and Whiting = *Lingulella* ? *huronensis minganensis* (Twenhofel and Whiting)

Mimella ? *minganensis* Twenhofel and Whiting = *Mimella minganensis* Twenhofel and Whiting

Petrocrania prona (Raymond)

Plectorthis ? *piger* (Billings) = *Mimella piger* (Billings)

Rafinesquina champlainensis minganensis (Twenhofel and Whiting) = *Glyptomena champlainensis minganensis* (Twenhofel and Whiting)

Rhynchocamara varians (Billings) = *Camerella varians* Billings

Rostricellula triangulata Cooper

Schizambon duplicimuratus Hudson = *Schizambon duplicimuratum* Hudson

Correlation of Mingan formation.—The age of the Mingan formation is without doubt the same as part of the Chazy group of New York; the only question is, with what part of the New York section does it correlate? The assemblage listed has nothing in common with the older Chazy (Day Point) and is undoubtedly all of younger age. In common with the Crown Point formation of New York, which overlies the Day Point formation, it contains *Schizambon duplicimuratum*, *Glyptorthis*, *Dactylogonia incassata*=*D. extensa* Cooper, *Rostricellula pristina*, *Onychoplecia longirostris*, and *Camerella varians*. The only definite link with the high Chazy (Valcour) is *Hesperorthis ignicula*, which is common in the lower 50 feet of the Mingan section. The reader must be reminded that the Valcour fauna is not yet completely known, particularly the portion in Quebec known as the St. Martin formation which contains many elements of the Crown Point as the *Glyptorthis* and *Dactylogonia*. Consequently the correlation is best made with Valcour and Crown Point rather than with Crown Point alone.

The fossils mentioned above as diagnostic of the Crown Point and Valcour formations are also reminiscent of species in the Lenoir of Tennessee and the McLish of Oklahoma. These formations are correlated (see below) with the Crown Point and Valcour of the New York section. This, therefore, seems the best assignment for the Mingan formation as well.

QUEBEC CITY REGION

The Lévis shales, on the south side of the St. Lawrence, underlie the village of Lévis and extend for considerable distances along the St. Lawrence Valley. In the vicinity of Lévis these shales contain several boulder beds in which are limestone erratics of several ages. Generally these boulders have never been dated as younger than late Canadian, but some of the species that have been taken

from them, when compared with brachiopods from the Mystic conglomerate, the Table Head of Newfoundland, and the Pogonip of Nevada, suggest that the dating should be with at least part of the Whiterock stage. Billings (1865) describes species dissolved out of silicified pieces from Limestone (boulder bed—No. 2) which are suggestive of post-Canadian brachiopods. These are *Orthidium gemmiculum*, *Nothorthis delicatula*, *Trematorthis lévisensis*, and *Pleurothis tritonia*. None of these genera have yet been taken from the highest Canadian (Black Rock).

Quebec City formation.—Much of Quebec City rests on the Quebec City formation which is in fault contact with the Sillery formation (Lower Ordovician-Canadian) and the Utica-Lorraine shales. The Quebec City formation also occupies the west side of the Island of Orleans in the St. Lawrence River. The rocks are hard, fine-grained limestones, dark shales, and thin limestone conglomerates. The thickness is not yet known and the structure and stratigraphic sequence have not been determined. According to Raymond (1913a, p. 29), pebbles in the limestone conglomerate are fossiliferous and contain *Bilobia pisum*, the trilobites *Tretaspis* and *Lonchodomas hastatus*, and the sponge *Nidulites*. The shales contain the graptolite *Corynoides calycularis*. These fossils suggest the Rysedorf conglomerate of New York, the lower part of the Edinburg formation of northern Virginia, and the lower part of the Chambersburg formation of Pennsylvania and Maryland. *Paterula amii* also occurs in the formation.

Through the kindness of René Bureau, Laval University, Quebec, I examined collections of brachiopods and trilobites from the Quebec City formation. One collection contained excellent specimens of *Sowerbyites* (*S.* sp. 1) and *Valcourea* sp. 5 which indicate affiliation of that part of the Quebec City formation with the Lincolnshire formation or the part of the Tellico formation that abounds in *Sowerbyites*.

Another collection loaned by Dr. Bureau contained a fine large *Oxoplecia* like *O. multcostellata* and *Paucicrura*-like punctate shells. These suggest the lower Edinburg and Chambersburg, but I was assured by Dr. Bureau that the *Sowerbyites* was younger than the assemblage with *Oxoplecia*. Possibly the various faunas come from boulders because the sequence in the Southern Appalachians is the reverse of that in the Quebec City.

On the chart, the Quebec City formation is interpreted as similar to the Rysedorf conglomerate and given the same age. From these few remarks it should be evident that the Quebec City formation invites close paleontological and stratigraphical study.

MONTREAL AND VICINITY

The lowest beds in the vicinity of Montreal of concern here are heavy-bedded, hard limestones belonging in the upper Chazy Group. These extend from Montreal to the vicinity of Hawkesbury, Ontario, along the Ottawa River. Little sand is present in the Chazy at this place. The limestone becomes thinner and thinner to the west and does not extend far west of Ottawa. It is believed that limestone is at least partially equivalent to the sands and shales of the Chazy in

the vicinity of Ottawa. The sands thin eastward while the limestones thin to the west.

St. Martin formation.—Dr. A. E. Wilson (1946a, p. 17) selected Cap St. Martin as the type section of the St. Martin member of the Aylmer formation. This type section is not far northwest of Montreal, and St. Martin is probably thus applicable as a formation name to the Montreal occurrences. *Camamotoechia plena* is abundant in some layers around Montreal and thus makes correlation with the Valcour formation of the New York sequence possible.

Brachiopods from the St. Martin formation are:

- Camamotoechia plena* (Hall) = *Rostricellula plena* (Hall)
Clitambonites porcia (Billings) = *Ptychopleurella porcia* (Billings)
Dactylogonia sp.
Glyptorthis transversa Cooper
 "Hebertella" *acuminata* (Billings)
Hebertella borealis Billings = *Mimella borealis* (Billings)
H. imperator (Billings) = *M. imperator* (Billings)
H. vulgaris Raymond = *M. vulgaris* (Raymond)
Lingula belli (Billings) = *Palaeoglossa belli* (Billings)
Lingulella cf. *L. huronensis* Billings
Placiomys platys (Billings) = *Multicostella platys* (Billings)
Rafinesquina incrassata Hall
 **Rafinesquina alternata* (Conrad). (Incorrectly identified.)
Rostricellula raymondi Cooper
Schizambon duplicimuratum (Hudson)
Zygospira acutirostris (Hall) = *Sphenotreta acutirostris* (Hall)

Pamelia formation.—Okulitch (1936, p. 127) reports a thin equivalent of this formation, not over 10 feet thick, consisting of dolomite and sandy limestone with green shale partings.

Lowville formation.—This formation consists of 16 feet of gray, thin- or thick-bedded limestone weathering dove gray, the layers separated by this shale partings. Fossils are common and Okulitch (1935) reports:

- Öpikina transitionalis* Okulitch
Rafinesquina grandis Okulitch = *Strophomena grandis* (Okulitch)

Chaumont formation.—Under this heading are placed rocks formerly called Leray in the vicinity of Montreal. This formation consists of thick beds of dark, light-gray-weathering limestone about 23 feet thick. The formation may extend to the east to within about 35 miles of Quebec. Brachiopods reported by Okulitch (1935) and others are:

- Dinorthis* sp.
Leptaena radialis Okulitch = *Cyphomena* ? *radialis* (Okulitch)
Pionodema sinuata Okulitch = Genus ?
Rafinesquina alternata (Conrad) = *Öpikina clara* (Okulitch) ?
R. clara Okulitch = *Ö. clara* (Okulitch)
R. grandis Okulitch = *Strophomena grandis* (Okulitch)
R. minnesotensis (N. H. Winchell) = *Öpikina minnesotensis* (N. H. Winchell)
R. transitionalis Okulitch = *Ö. transitionalis* (Okulitch)
R. wagneri Okulitch = *Ö. wagneri* (Okulitch)

R. williamsi Okulitch = *Ö. wagneri* (Okulitch)

**Rhynchotrema increbescens* (Hall)

Strophomena corrugata Okulitch = *Strophomena okulitchi* Cooper

**S. emaciata* Winchell and Schuchert

**Strophomena incurvata* (Shepard)

No formations correlative with Rockland are known in the vicinity of Montreal.

OTTAWA VALLEY, VICINITY OF OTTAWA

Ottawa and vicinity have long been known for the interesting fossils described from the Ordovician rocks that underlie the city and surrounding country. Here an interval from the Lower Ordovician (late Canadian) through the Richmond is exposed.

Aylmer formation.—This name was used by Raymond (1905, p. 362) for the Chazy rocks in this region. Recently the formation has been divided into two formations, one of shale and sandstone, the other of limestone, which are at least partial facies of each other and would be better considered as members of the Aylmer formation. The Aylmer formation extends from L'Orignal west to Alumette Island, about 115 miles. In its westernmost localities the limestone is not present.

Rockcliffe member of Aylmer formation.—This name is applied by A. E. Wilson (1946a, p. 17) to the lower part of the Aylmer formation, which consists of predominantly green shale containing lenses of fine, gray sandstone. It is named for Rockcliffe Park, just east of Ottawa. In places the basal layer is a conglomerate. This member has an average thickness of about 160 feet.

Brachiopods reported are:

Camarotoechia orientalis Billings = *Rostricellula orientalis* (Billings)

C. plena (Hall) = *R. plena* (Hall)

Hebertella imperator (Billings) = *Mimella imperator* (Billings)

Lingula lyelli Billings = *Ectenoglossa ? lyelli* (Billings)

Lingulella rugosilinea Cooper

Lingulella sp. 6

Mimella latistriata Wilson

Rostricellula wilsonae Cooper

St. Martin member of Aylmer formation.—This member is named by A. E. Wilson (1946a, p. 19) from Cap St. Martin, north of Montreal, where I give it formation rank. The member consists of about 20 feet of gray or brown shales, gray-green sandstones and impure limestones, and dolomites which weather to a rusty brown. East of Ottawa, deep wells indicate that the member thickens to 150 feet. Dr. Wilson reports four zones in the St. Martin, the lowest containing several species of *Hebertella* (= *Mimella*) with a few specimens of *Camarotoechia* (= *Rostricellula*) *orientalis*. In the second zone the proportion of the two genera is more nearly equal; in the third zone *R. orientalis* becomes much more abundant. The fourth zone abounds in *Camarotoechia* (= *Rostricellula*) *plena* with *R. orientalis*.

Correlation of Aylmer formation.—Raymond (1905, p. 362-364) has shown

that the Aylmer formation of the Ottawa Valley region is to be correlated with the Valcour formation, uppermost Chazy. This correlation is chiefly based on the common presence of *Rostricellula plena* in the Ottawa formation and the Valcour of New York. Few other fossils are common to the two sequences because the facies are quite unlike.

Ottawa group (or formation)

This name is taken from the Ottawa Valley and embraces a number of units that were hitherto regarded as formations. Dr. Wilson believes that the fossils indicating certain time units do not conform with lithologic boundaries of the formations that had been previously defined. In order to make Ottawa stratigraphy more practical and more easily understood Dr. Wilson recommends abandonment of the formations that had hitherto been recognized: Pamela, Lowville, Leray, Rockland, Hull, Sherman Fall, and Cobourg. This problem occurs in many sequences that have been refined by paleontological work, such as the Southern Appalachians. Here a number of geologists have attempted to divide the Chickamauga limestone on the basis of fossils, but shifting facies make boundaries cloudy and the geologist uninitiated in fossils finds the separation of formations difficult. This has inspired a recent effort to revive the name Chickamauga as a formation. Inasmuch as one purpose of the present work is to portray in detail brachiopod assemblages, I prefer to recognize the named faunas in both the Ottawa and Chickamauga limestones, realizing at the same time that the boundaries between divisions are in many cases uncertain.

Pamelia formation.—In the Ottawa Valley this formation is composed of two divisions, the lower one characterized by its large proportion of sandstones and sandy shales. Thin layers of dark limestone, some fine-grained and others dolomitic, also occur. The upper Pamela consists mainly of gray limestone and beds of dolomitic material, separated by shale partings. A few sandy layers appear, but the upper beds are distinguished from the lower ones by a lesser sand content. The division between the upper and lower Pamela and between the Aylmer underneath and the Lowville above the Pamela are transitional and difficult to determine. The two divisions of the Pamela are estimated to attain at least 69 feet in thickness. Fossils are rare in the Pamela but one of the important ones is the trilobite *Bathyurus extans* Hall. Brachiopods reported by A. E. Wilson (1946a, pp. 3-9) are:

Camerella panderi Billings = *Idiospira panderi* (Billings)

Lingulella narrawayi Wilson

Strophomena canadensis Wilson

**S. filitexta* Hall

S. minuta Wilson

S. venustula Wilson

Correlation of Pamela formation.—The Pamela of the Ottawa Valley has many characteristics of the New York or type Pamela and is probably related to it. Although the Pamela was placed in the Chazy by Ulrich (1911, pl. 27) its affinities seem rather to be with the overlying Lowville than with the Chazy.

This view was expressed by A. E. Wilson (1932) as well as others. The lithology is completely unlike that of the Aylmer formation below, and the few fossils known are quite unlike those of the lower beds. The disappearance of the *Rostricellula* of the Aylmer sees the appearance of new types. Wilson records a number of species of *Strophomena* which is a genus not yet seen in rocks deposited in the Marmor Stage. This genus, too, links the Pamelia to the overlying Lowville. As a matter of fact it is doubtful if the formation is really separable from the Lowville here or elsewhere on a paleontological basis.

Lowville formation.—In the Ottawa Valley the Lowville formation is 20 to 30 feet thick and consists of the usual light-gray limestone with an occasional shaly bed. It abounds in the coral *Tetradium cellulosum*, and the trilobite *Bathyrurus extans* is a common fossil. Brachiopods are numerous in the formation and have been listed by A. E. Wilson (1946a, pp. 3-9) as follows:

- Dalmanella rogata* (Sardeson) = *Paucicrura rogata* (Sardeson)
- Doleroides gibbosus* (Billings)
- D. pervetus ottawanus* Wilson = *D. ottawanus* Wilson
- Eridorthis rocklandensis* Wilson
- Glyptorthis bellarugosa* (Conrad). (Identification doubtful.)
- Lingula narrawayi* Wilson = *Lingulella narrawayi* (Wilson)
- Opikina sinclairi* Wilson
- O. subtriangularis* Wilson
- O. tumida* Wilson
- Rafinesquina alternata plana* Wilson
- Rhynchotrema ainsliei* (N. H. Winchell) = *Rostricellula ainsliei* (N. H. Winchell)
- R. increbescens* (Hall). (Identification doubtful.)
- Schizocrania filosa* (Hall)
- **Sowerbyella sericea* (Sowerby)
- **Strophomena filitexta* Hall
- S. venustula* Wilson
- Zygospira recurvirostris* (Hall)

Correlation of Lowville formation.—This formation is evidently the same as the Lowville of New York, but the list presented above contains numerous Trenton species and types. In the Appalachians *Zygospira* is very rare prior to the Witten (equivalent to Rockland), and typical *Rhynchotrema increbescens* is certainly a post-Lowville (probably post-Rockland) species.

Chaumont formation.—In the Ottawa Valley this formation had hitherto been called Leray formation (see below). It is a heavy-bedded, dark-gray limestone with some shale partings but little chert in its northern manifestation. The formation is about 30 feet thick. A. E. Wilson (1946a, pp. 3-9) lists the following species:

- **Camerella hemiplicata* (Hall)
- Dalmanella rogata* (Sardeson) = *Paucicrura rogata* (Sardeson)
- Doleroides gibbosus* (Billings)
- D. pervetus ottawanus* Wilson = *Doleroides ottawanus* Wilson
- Eridorthis rocklandensis* Wilson
- Hesperorthis tricenaria* (Conrad)
- Lingula obtusa* Hall = Genus ?
- L. rectilateralis* Emmons = Genus ?

- L. riciniformis* Hall = Genus ?
Microtrypa altilis Wilson
Opikina wagneri robusta Wilson
 **Rafinesquina alternata* (Conrad)
R. alternata platys Wilson
R. normalis Wilson
R. ottawaensis Wilson
 **Rhynchotrema ainsliei* (N. H. Winchell)
 **R. increbescens* (Hall)
R. intermedium Wilson
Schizotreta canadensis Wilson
 **Sowerbyella punctostriata* (Mather)
 **S. sericea* (Sowerby)
 **Strophomena delicatula* Fenton
 **S. cf. S. dignata* Fenton
 **S. filitexta* Hall
S. filitexta crenulata Wilson
S. filitexta obesa Wilson
S. minuta Wilson
S. mollis Wilson
S. planumbona praecepta Wilson
S. rotunda Wilson
S. thalia Billings
S. venustula Wilson
Trigrammaria trigonalis prima Wilson
Zygospira deflecta (Hall)
Z. recurvirostris (Hall)

Correlation and discussion of faunal list.—This list is composed only of those species placed by Wilson in the "Leray column." Those species placed on the line "Leray-Rockland" are added to the Rockland list because many Trenton forms appear on the line that elsewhere are unknown in the Chaumont. Even with this precaution the list above contains many Trenton forms that are not known in the Chaumont elsewhere such as *Paucicrura rogata*, *Sowerbyella punctostriata*, *Rafinesquina alternata* and varieties or subspecies, *Strophomena filitexta*, *Rhynchotrema increbescens*. Despite these uncertainties the formation probably is the equivalent of the Chaumont of New York.

Rockland formation.—This is the type region for this formation which here consists of about 35 feet of heavy-bedded, gray, somewhat crystalline limestone interbedded with shale at some places. The brachiopods are listed below; those prefaced by a double asterisk are from Leray-Rockland beds where difficulty was experienced in separating the two. A single asterisk indicates a doubtful identification as in other lists.

- Camerella hemiplicata* (Hall) = *Parastrophina hemiplicata* (Hall)
C. panderi (Billings) = *Idiospira panderi* (Billings)
 ***C. volborthi* Billings
 ***Crania trentonensis* Hall
Dalmanella paquettensis (Sinclair) = *Onniella paquettensis* Sinclair
D. rogata (Sardeson) = *Paucicrura rogata* (Sardeson)
 ***Dinobolus canadensis* (Billings) = *Obolellina canadensis* (Billings)
 ***D. erectus* Wilson = *O. erecta* (Wilson)

- ***D. magnificus* (Billings) = *O. magnifica* Billings
Didymelasma abruptum Cooper
Dinorthis browni Wilson
D. iphigenia (Billings)
D. iphigenia minor Wilson
D. pectinella (Emmons)
D. cf. D. p. sweeneyi (N. H. Winchell) = *Dinorthis cf. D. sweeneyi* (N. H. Winchell)
D. regularis Wilson
 ***Doleroides gibbosus* (Billings)
 ***D. pervetus ottawanus* Wilson = *Doleroides ottawanus* Wilson
 ***Eichwaldia subtrigonalis* Billings
 ***Glyptorthis bellarugosa* (Conrad)
Hesperorthis tricenaria (Conrad)
Microtrypa altilis Wilson
M. ? nasuta Wilson
 ***Öpikina ampla* Wilson
 ***Ö. gloucesterensis* Wilson
 ***Ö. hemispherica* Wilson
 ***Ö. inquassa* (Sardeson)
Ö. ovalis Wilson
Ö. platys Wilson
Ö. rugosa Wilson
 ***Ö. rugosa avita* Wilson
 ***Ö. septata borealis* Wilson
 ***Ö. sinclairi* Wilson
Ö. subtriangularis Wilson
Ö. transitionalis (Okulitch)
 ***Ö. tumida* Wilson
Platystrophia amoena McEwan
P. a. longicardinalis McEwan
P. trentonensis McEwan
 ***Plectorthis ottawaensis* Wilson
 ***P. pulchella* Wilson
Rafinesquina alternata (Conrad)
 ***R. a. alata* Wilson
 ***R. a. intermedia* Wilson
R. a. plana Wilson
 ***R. a. semiquadrata* Wilson
 ***R. a. transversa* Wilson
R. hullensis Wilson
 ***R. lennoxensis* Salmon
R. opeongoensis Wilson
 ***R. orleansensis* Wilson
R. patula Wilson
 ***R. robusta* Wilson
 ***R. subcamerata* Wilson
R. ottawaensis Wilson
 ***R. salmoni* Wilson
 ***R. sinuata* Wilson
Rhynchotrema increbescens (Hall)
R. ottawaense (Billings) = *Drepanorhyncha ottawaensis* (Billings)
Schizocrania filosa (Hall)
Skenidioides billingsi Schuchert and Cooper
S. ? merope (Billings)

Sowerbyella punctostriata (Mather)

**S. sericea* (Sowerby). (Identification doubtful.)

***Strophomena billingsi* Winchell and Schuchert

S. filitexta Hall

S. f. obesa Wilson

S. magna Wilson

S. ? millionensis affinis Wilson

S. rotunda Wilson

S. venustula Wilson

Trematis terminalis (Emmons)

Trigrammaria trigonalis prima Wilson

Triplecia cuspidata (Hall) = *Triplexia cuspidata* (Hall)

T. extans (Emmons) = *T. extans* (Emmons)

***Vellamo trentonensis* (Raymond)

Zygospira recurvirostris (Hall)

Correlation of Rockland formation and remarks on the listed brachiopods.—

The Rockland formation has hitherto been correlated with the upper part of the Decorah of the Mississippi Valley, but the above list indicates that the Ottawa Valley Rockland formation contains elements of the Prosser formation of the Mississippi Valley as well. Prosser elements are: *Vellamo*, *Platystrophia*, *Onniella*, and *Parastrophia*.

The discrepancies in the above list are interpreted as defects in the listing rather than indicating that the Rockland formation correlates with the Decorah and Prosser of the Mississippi Valley. If this were the case the Hull and Sherman Fall formations would need to be completely reevaluated. The work of Kay has shown these to be consistently identified over wide areas. The writer has therefore placed the Rockland in the position and correlation given it by Kay (1937).

HEAD OF THE ST. LAWRENCE VALLEY IN NEW YORK AND ADJACENT CANADA

This area includes the Black River Valley of New York, the Watertown area of New York, and the adjacent part of Ontario along the north side from Kingston westward. The Ordovician about Coboconk described by Okulitch (1939) is on the westward side of the belt. The Black River rocks of this area were described by Young (1943) and the Early Trentonian by Kay (1937). The area is a well-known one numbering several formations almost as old as the science of geology in New York. From the bottom up the section is: Pamelia, Lowville, Chaumont (including several members), Rockland (with two members: Selby and Napanee).

Pamelia formation.—This formation has its greatest thickness in Jefferson County, N. Y., where it is 150 feet thick. It consists of a lower division of about 70 feet composed of basal conglomerate and arkosic sandstones, dark-gray fossiliferous rock, sublithographic limestone interbedded with gray dolomitic limestone. The upper division is about 80 feet thick, of light-gray or whitish earthy limestone interbedded with gray magnesian and sublithographic limestone. In both divisions the dolomitic and earthy limestones weather to a buff or yellowish-brown hue, and are thus readily distinguished from the overlying Lowville.

The formation thins to the east and west of its area of greatest thickness. It thins to disappearance in Oneida County, N. Y., to the east, and Okulitch reports the Shadow Lake formation, equivalent of the Pamelia, as only 18 feet thick in the vicinity of Coboconk, Ontario.

The upper member is more persistent than the lower one. The formation is also marked by shallow-water phenomena such as ripple marks and mud cracks. Fossils are rare in this formation. *Cryptophragmus* is present in the lower division. *Ancistrorhyncha* sp.=*A. costata* Ulrich and Cooper and *Zygospira recurvirostris* (Hall) are the only brachiopods reported by Young (1943, p. 234) in his extensive studies of this formation.

The age and affinities of the Pamelia formation have been the subject of considerable debate (Young, 1943, p. 151) but it is generally conceded now that it has its strongest ties with the Lowville rather than with the Chazy group. This is certainly the indication given by the few fossils that have been taken from it. The two mentioned brachiopods place the Pamelia fairly high. *Zygospira* in the Appalachians is not known until the time of Witten deposition, but *Ancistrorhyncha* is slightly older. The Pamelia appears to be a part of the Lowville and probably varies in age from place to place.

Lowville formation.—This name has been widely used in the eastern United States and Canada as a formation name, but such use should be discouraged outside of New York, Ontario, and Quebec. Only in these latter regions can the formation be shown to be a laterally continuous unit. Elsewhere the name has use only in a facies sense for so-called dove limestones.

In its type region the formation is 34 feet thick but a short distance away it is 54 feet thick. It thins to the southeast to 6 to 10 feet in the Mohawk Valley. To the west it is 40 feet thick at Kingston and 47 feet at Marmora, Hastings County. Okulitch records the Gull River formation, equivalent of the Lowville at Coboconk, as 45 feet. The formation is divisible throughout its extent into a lower and upper part, the former generally thin bedded and the latter heavy bedded. In Ontario the Lowville usually is shalier than in New York.

The lithologic types seen in the Lowville are dove-gray and dark sublithographic limestones usually in thick beds and often with calcite-filled worm borings and tangled nets of the coral *Tetradium cellulosum*. Dark semicrystalline and argillaceous limestones are often interbedded with the sublithographic beds. Granular beds and oolites also occur. The lower beds are often conglomeratic and the formation rests disconformably on the Pamelia or on Canadian rocks where the Pamelia has been overlapped. Mud-cracked and ripple-marked shales indicate shallow-water deposition.

Fossils are fairly common in Lowville rocks but the preservation is often poor and it is difficult to extract specimens from the sublithographic limestones. The following brachiopods are reported:

**Rafinesquina minnesotensis* = *Öpikina*

**Rhynchotrema* sp. cf. *increbescens* (Hall)

Strophomena sp.

Zygospira recurvirostris (Hall)

Chaumont formation.—This name was proposed by Kay (1929a, p. 644) for rocks occupying the interval between the Lowville and the Rockland in Jefferson County, N. Y. The name was made to include three members in ascending order: Leray, Glenburnie, and Watertown. The Leray member consists of 13 feet of heavy-bedded, dark brownish-gray to black limestone containing considerable chert. This member in the type region of the Chaumont is separated from the Watertown by 2 feet of fossiliferous shale, the Glenburnie. The Watertown limestone, or top member, comprises 13 feet of massive limestone without chert except for the lower part. Outside the type area it is difficult to separate the Leray and Watertown.

The Chaumont formation thins to the south and east and is absent at Middleville, N. Y., and in the Mohawk Valley. When the formation is followed to the west it tends to become thinner bedded, browner, and with chert absent, irregularly spread through it, or confined to the top. The formation is also less easy to separate from the Lowville but the faunal content is persistent. The formation attains as much as 25 feet in thickness north of Peterborough, Ontario, but thins again in the vicinity of Lake Simcoe.

Brachiopods are fairly common and varied in the Chaumont formation:

**Camerella volborthi* Billings

Doleroides gibbosus (Billings)

D. pervetus (Conrad)

**Glyptorthis bellarugosa* (Conrad)

**G. insculpta* (Hall)

Hesperorthis tricenaria (Conrad) = *H. concava* Cooper

Hesperorthis sp.

Leptaena radialis Okulitch = *Cyphomena ? radialis* (Okulitch)

Pionodema sp. 1

Rafinesquina clara Okulitch = *Öpikina clara* (Okulitch)

R. minnesotensis (N. H. Winchell) = *Öpikina minnesotensis* (N. H. Winchell)

**Rhynchotrema* sp. cf. *increbescens* (Hall)

**Strophomena* sp. cf. *delicatula* Fenton

Strophomena sp.

"*Valcourea deflecta* (Conrad)"

Zygospira recurvirostris (Hall)

Rockland formation.—This term refers to beds overlying Chaumont and underlying Hull limestone. The formation is typically developed in Ottawa Valley but occurs also in western New York and Ontario. The formation is 64 feet thick east of Dexter, N. Y., and is of similar thickness in Lennox and Addington County, Ontario. Two members have been distinguished in New York and Ontario: Selby member and Napanee member.

Selby member of Rockland formation.—Kay (1937, p. 252) proposed this name for dark-gray to black, medium- to fine-textured, petroliferous thin-bedded, buff-weathering limestones characterized by the brachiopod *Doleroides ottawanus* Wilson. The member is recognized in New York in Jefferson County where it extends southeast to about East Martinsburg in the Black River Valley, in Lewis County. At Lowville, N. Y., it is about 15 feet thick. It is exposed in

southern Lennox and Addington County, Ontario, but is overlapped to the west. Brachiopods are:

**Dalmanella rogata* (Sardeson) = *Paucicrura rogata* (Sardeson)

Doleroides ottawanus Wilson

D. pervetus (Conrad)

**Hesperorthis tricenaria* (Conrad)

Rafinesquina alternata (Conrad)

Rhynchotrema sp.

**Sowerbyella curdsvillensis* (Foerste)

Strophomena sp.

Napanee member of Rockland formation.—This member was named by Kay (1937, p. 255) after Napanee, Ontario. The member is well exposed in western New York and central Ontario. At the type section it is 34 feet of gray-blue, medium-textured, heavy-ledged limestone with shaly partings, particularly in the lower part. In New York it occurs at all areas having the Selby member, but is absent from the Western Canada Creek and Mohawk Valleys except for local occurrences at Inghams Mills and Newport Quarry in Herkimer County. Westward from Napanee it extends to Peterborough County, Ontario. Still farther west it is thought to be represented by the Coboconk limestone. Brachiopods recorded from the Napanee member are:

Camerella obesa Cooper

C. volborthi Billings

Dalmanella rogata (Sardeson) = *Paucicrura rogata* (Sardeson)

Hesperorthis tricenaria (Conrad)

Parastrophina hemiplicata (Hall)

Protozyga exigua (Hall)

Rafinesquina alternata (Conrad)

"*R.*" *inquassa* (Sardeson) = *Öpikina inquassa* (Sardeson)

R. lennoxensis Salmon

R. olliformis Salmon

Sowerbyella punctostriata (Mather)

**Strophomena filitexta* (Hall)

Trigrammaria wilsonae Cooper

Triplisia cuspidata (Hall)

SECTION AT COBOCONK, CENTRAL ONTARIO

In central Ontario Black River–Rockland rocks make a narrow belt extending east-west from Kingston to Victoria Harbour on Georgian Bay. Sections studied by Okulitch (1939) are located on Highway 35 between Coboconk and Norland. Four formations in ascending order are recognized: Shadow Lake, Gull River, Moore Hill, and Coboconk.

Shadow Lake formation.—This basal formation, 18 feet thick, consists of unfossiliferous purple and green shales and magnesian limestones or dolomites. The position of the formation resting on the pre-Cambrian and the lithologic character are suggestive of the Pamela formation of New York.

Gull River formation.—Compact, light-gray, aphanitic limestone, 45 feet

thick, with some magnesian and shaly limestone at the base. Fossils are rare but the following brachiopods are recorded:

Rafinesquina cf. *alternata* (Emmons) = *R.* cf. *R. trentonensis* (Conrad)

R. clara Okulitch = *Öpikina clara* (Okulitch)

R. minnesotensis Winchell = *Ö. minnesotensis* (N. H. Winchell)

**Strophomena incurvata* (Shepard)

Strophomena sp.

Zygospira recurvirostris (Hall)

Presence of *Cryptophragmus* and some other fossils suggests lower Lowville.

Moore Hill formation.—Consists of about 20 feet of limestone containing “birdseyes” and in the lower part thin aphanitic beds and thin greenish layers. *Tetradium cellulosum*, *Lambeophyllum*, and *Stromatocerium* are common. The brachiopods recorded are:

**Rafinesquina* cf. *alternata* (Emmons) = *R.* cf. *R. trentonensis* (Conrad)

R. clara Okulitch = *Öpikina clara* (Okulitch)

**R. minnesotensis* (N. H. Winchell) = *Öpikina minnesotensis* (N. H. Winchell)

Rafinesquina n. sp.

**Strophomena filitexta* Hall

Zygospira recurvirostris (Hall)

Coboconk formation.—This formation consists of 20 feet of moderately heavy-bedded, aphanitic to fine-grained limestone, gray-brown to gray and weathering brown. The uppermost bed is of fine- to medium-grained limestone containing a fauna with some different species from those below. *Cryptophragmus* is present in the lower beds but *Receptaculites occidentalis*, *Calapoecia canadensis*, *Hesperothis tricenaria*, and *Maclurites logani* occur in the top layer. Brachiopods are:

Leptaena cf. *radialis* Okulitch = *Cyphomena* cf. *C. radialis* (Okulitch)

Rafinesquina alternata (Conrad) = *Rafinesquina trentonensis* (Conrad)

R. clara Okulitch = *Öpikina clara* (Okulitch)

R. minnesotensis (N. H. Winchell) = *Ö. minnesotensis* (N. H. Winchell)

Strophomena cf. *corrugata* Okulitch

**S. filitexta* Hall. (Identification doubtful.)

Zygospira recurvirostris (Hall)

According to Okulitch the lower beds have affinities with Chaumont but Kay (1937, p. 256) argues that the Coboconk is of Rockland age. Okulitch believes that the only Rockland elements occur in the uppermost bed as listed above. He believes further that the whole formation is correlative to Chaumont age because the characteristic Rockland elements are missing. The only Rockland he will concede is the uppermost bed. On the chart the entire Coboconk is correlated with the Rockland.

MANITOULIN ISLAND REGION

Foerste (1912a, pp. 38-41) described the stratigraphy of Cloche Island and others of the Manitoulin Group and assigned ages to several of the beds. Kay (1937, pp. 257-259) discusses the same sequence but assigns the ages differently from Foerste. Two of the three formations were named by Foerste in ascending order: Lowville, Swift Current, and Cloche Island.

Lowville formation.—The lowest Ordovician rocks of the region are exposed on the west side of Cloche Peninsula and consist of at least 60 feet of reddish clay shale that produced a few fossils. The only brachiopod recorded is *Lingulella clochensis* (Foerste).

Swift Current formation.—This consists of a possible 50 feet of section according to Foerste's estimate. The lower beds are reddish limestone or dolomite with fragmental material at the base in which are mixed a number of Ordovician species. The higher beds are of fine-grained, white, "birdseye" limestone poor in fossils. Except for the basal beds, few fossils occur except at the base of the white "birdseye" limestone where the same fauna as that at the base is found. Foerste lists the following brachiopods:

Pionodema sp.

Rhynchotrema ainsliei (N. H. Winchell) = *Rostricellula rotundata* Cooper

Foerste suggests that the Swift Current formation resembles the Tyrone of Kentucky but Kay refers it to the Chaumont division of the Black River.

Cloche Island formation.—This formation is composed of 55 feet of light-gray, heavy-bedded limestone with shaly beds in the lower part. It occupies most of the southern part of Cloche Island and may extend to Delta County, Mich. Brachiopods listed by Kay and others are:

Camerella panderi Billings = *Idiospira panderi* (Billings)

C. volborthi Billings

Dalmanella rogata (Sardeson) = *Paucicrura rogata* (Sardeson)

Dinorthis sweeteyi (N. H. Winchell)

Doleroides pervetus (Conrad)

Glyptorthis bellarugosa (Conrad)

Hallina sp.

Hesperorthis tricenaria (Conrad)

Rafinesquina alternata (Conrad) = *Rafinesquina trentonensis* (Conrad)

"*R.*" *inquassa* (Sardeson) = *Opikina inquassa* (Sardeson)

Rhynchotrema increbescens (Hall)

Rostricellula rotundata Cooper

Sowerbyella punctostriata (Mather)

**Strophomena* sp. *S. emaciata* Winchell and Schuchert

**S. filitexta* (Hall)

Kay (1937, p. 257) correlates this formation with the Rockland of Ottawa and with the Guttenberg of the upper Mississippi Valley section. The fossils recorded above, if correctly identified, indicate that the Cloche Island formation may embrace a somewhat higher part of the Trenton as well. The Cloche Island on the chart is made equivalent to the Rockland of the Ottawa Valley, otherwise difficulties arise with the higher formations. All these faunas need revision.

3. CHAMPLAIN, MOHAWK, AND HUDSON VALLEYS

CHAMPLAIN VALLEY (WEST SIDE)

In and about the village of Chazy, Clinton County, N. Y., on the west side of Lake Champlain, a considerable body of fossiliferous rocks, nearly 900 feet on Valcour Island, has long been known as the Chazy limestone (here called

Chazy group). The sequence is best displayed on Valcour Island, N. Y., but good sections are also known at Crown Point, N. Y., and on Isle la Motte, Vt. The sequence was early separated into three divisions by Brainerd and Seely (1896) who designated them A, B, and C. Later, Cushing (1905) proposed to substitute the name Day Point for division A, Crown Point for division B, and Valcour for Division C. Raymond and others have expressed dissatisfaction with these names because the terms applied do not accord with the sections at the various places. For example, the section at Day Point belongs to the Crown Point formation. This is really not an issue because the Cushing names were made as substitutes for the Brainerd and Seely divisions and the reference sections must be those given by Brainerd and Seely for their divisions rather than the locations from which Cushing took his names.

Raymond (1905) made a detailed study of the fauna of the Chazy rocks on the west side of Lake Champlain and further divided the beds into faunal zones.

Day Point formation.—This formation consists of gray sandstone interbedded with layers of slate or occasional limestone layers near the base. These beds are succeeded by nodular limestone that alternates with tough slate. The next division is composed of limestone often packed with *Orthambonites ? exfoliata* (Raymond). The uppermost limestone is in beds 8 to 20 inches thick and has many beds of echinoderm fragments. The whole sequence is 338 feet thick.

Brachiopods recorded from the Day Point formation are:

Camerella ? costata Billings

C. longirostris Billings = *Onychoplecia longirostris* (Billings)

Lingulella brainerdi (Raymond)

Orthis acutiplicata Raymond = *Orthambonites acutiplicatus* (Raymond)

O. exfoliata Raymond = *Orthambonites ? exfoliatus* (Raymond)

Palaeoglossa belli (Billings)

Rafinesquina incrassata = *Dactylogonia incrassata* (Hall)

Schizambon ? duplicimuratus Hudson = *S. ? duplicimuratum* Hudson

Correlation of Day Point formation.—The Day Point for the most part constitutes Raymond's *Hebertella exfoliata* zone or division I. This zone contains brachiopods and other fossils that are confined to it. At present no satisfactory correlation of this formation can be stated. The fauna seems not to have any connections with that of the Table Head or its equivalents and it is not assignable to the Whiterock stage. The listed species are mostly related to higher Crown Point forms.

Crown Point formation.—This formation consists of 200 to 400 feet, mostly of dark fine-grained, heavy-bedded limestone with occasional beds of light-gray coarsely crystalline limestone. Brachiopods are common:

Camarella longirostris Billings = *Onychoplecia gracilis* (Raymond)

Camerella varians Billings

Camarotoechia pristina Raymond = *Rostricellula pristina* (Raymond)

Clitambonites multicostatus Hudson = *Atclelasma ? multicostatum* (Hudson)

Hebertella bellarugosa (Conrad) = *Glyptorthis sulcata* Cooper

H. vulgaris Raymond = *Mimella vulgaris* (Raymond)

Leptaena incrassata Hall = *Dactylogonia incrassata* (Hall)
Leptellina primaria Cooper
Lingulella columba Raymond
Mimella nucleoidea Cooper
M. ulrichi Cooper
Multicostella platys (Billings)
Orthidium ? *lamellosum* Raymond = *Ptychopleurella lamellosa* (Raymond)
Orthis costalis Hall = *Hesperorthis* ? *costalis* (Hall)
O. ? *porcia* Billings = *Ptychopleurella porcia* (Billings)
Petrocrania prona (Raymond)
Rafinesquina champlainensis Raymond = *Macrocoelia champlainensis* (Raymond)
R. distans Raymond = *Glyptomena* ? *distans* (Raymond)
R. fasciata Hall = *Dactylogonia incrassata* (Hall)
Rhynchonella ? *acutirostris* Hall = *Sphenotreta acutirostris* (Hall)
Schizambon duplicimuratum Hudson
Strophomena prisca Raymond = *Glyptomena* ? *prisca* (Raymond)
Triplecia gracilis Raymond = *Onychoplecia gracilis* (Raymond)
Valcourea strophomenoides (Raymond)
Zygospira acutirostris (Hall) = *Sphenotreta acutirostris* (Hall)

Correlation of Crown Point formation.—This formation is correlated with parts of the Mingan formation, the McLish formation, and the Lenoir formation. All the named formations also have elements of the Valcour fauna in them and all are correlated with the Crown Point-Valcour interval.

Valcour formation.—This is division 3 of Raymond, or the *Camarotoechia* (= *Rostricellula*) *plena* zone. The formation contains massive dove-colored limestone at the base followed by impure limestone abounding in *Rostricellula plena*. The formation is capped by sandy magnesian limestone passing into sandstone. It is 172 feet thick. The following brachiopods have been reported:

Camarotoechia major Raymond = *Rostricellula major* (Raymond)
C. plena (Hall) = *R. plena* (Hall)
Dactylogonia sp.
Glossina belli Billings = *Palaeoglossa belli* (Billings)
Hebertella costalis (Hall) = *Hesperorthis* ? *costalis* (Hall)
Mimella transversa Cooper
M. valcourensis Cooper
Orthis ignicula Raymond = *Hesperorthis ignicula* (Raymond)
Rostricellula plena altilis (Hall)
R. plena plicifera (Hall)

Correlation of Valcour formation.—Except for the continuation of this formation in Canada, no other Chazy beds are quite like it. In the Appalachians the Lenoir formation contains elements of the Valcour as well as of the Crown Point. This is true also of the Mingan and McLish faunas. Furthermore, the Valcour contains species and genera that are related to Crown Point species or holdovers from that formation. It seems best, therefore, to include the Valcour formation with the Crown Point formation as a unit in correlation.

Lowville formation.—This formation is represented by only 5 feet or a little more of heavy-bedded (6 to 12 inches) dove-colored limestone. The "birds-eyes" characteristic of the formation occur throughout. The only brachiopod reported is *Zygospira recurvirostris* (Hall).

Chaumont formation.—In the Crown Point section (Raymond, 1902, p. 21), Kay (1937, p. 259) states that beds 19 to 23 should be assigned to the Chaumont. The thickness is about 26 feet. Raymond records the following brachiopods.

Dalmanella subacquata pervetus = *Doleroides pervetus* (Conrad)

Hesperorthis ? *costalis* (Hall) ?

**Plectorthis plicatella* (Hall)

**Rafinesquina alternata* (Conrad)

**Rhynchotrema inaequivalve* (Castelnau)

**Strophomena incurvata* (Shepard)

Zygospira recurvirostris (Hall)

Some of the above brachiopods are undoubtedly incorrectly identified, but it is not possible to make revision without studying a collection from this formation. *Rafinesquina* is generally absent from the Chaumont. If the fossils are correctly identified the limestone might be assigned to the overlying Amsterdam formation.

Amsterdam formation.—According to Kay (1937, p. 259) beds 24 and 25 of Raymond's Crown Point section plus the lower 4 feet of bed 26, about 17 feet in all, belong to the Amsterdam formation of Cushing which is better displayed in the lower Mohawk Valley. The following brachiopods are reported by Raymond:

**Dalmanella testudinaria* = *Paucicrura* ? sp. ?

**Dinorthis pectinella* (Emmons)

Plectorthis plicatella (Hall)

Rafinesquina alternata (Conrad) = *Rafinesquina trentonensis* (Conrad)

**Strophomena incurvata* (Shepard)

Zygospira recurvirostris (Hall)

If the brachiopods recorded above are correctly identified, assignment of this manifestation of the Amsterdam formation to a position equivalent to high Decorah (Ion) would be necessary, but this is not in accord with faunas of overlying formations.

Isle la Motte formation.—Kay (1937, pp. 259, 260) assigns the remainder of bed 26 and beds 27 and 28, about 16 to 20 feet of limestone, to the Isle la Motte formation. At the type section this is 10 feet of black, gray-weathering, heavy-bedded limestone. This formation extends to the south to the vicinity of Glens Falls, N. Y. Brachiopods listed by Raymond are:

Dalmanella testudinaria = Probably *Paucicrura*

Dinorthis pectinella (Emmons)

Glossina trentonensis (Conrad)

Rafinesquina alternata (Conrad) = *Rafinesquina trentonensis* (Conrad)

Strophomena incurvata (Shepard)

Triplecia extans (Emmons) = *Triplecia cuspidata* (Hall)

Correlation of Isle la Motte formation.—Kay (1937, p. 261) correlates the Isle la Motte formation with the Rockland of Ontario because of *Triplecia* and other fossils such as *Maclurites logani* and *Columnaria halli*. If the recognition of these formations in the Crown Point section is correct the position of the Amsterdam formation is made clear between the Chaumont and Isle la Motte.

It also means that listed fossils from the lower formation are either long ranged or misidentified. The Isle la Motte formation is overlain by the Larrabee formation which is correlated with the Hull formation of Ontario and western New York because of abundance of *Parastrophina*.

PHILLIPSBURG THRUST SLICE

In southern Quebec, just north of the Vermont border and on the east side of Lake Champlain, a long sequence of Ordovician rocks is revealed in the Phillipsburg slice which is thrust over the Iberville shale. Most of this slice is composed of Lower Ordovician formations but these are overlain by the Mystic conglomerate or breccia (Clark, 1934, pp. 6, 7). This formation is composed of limestone boulders of varying size, often quite large. These boulders are of several ages but the ones of immediate interest here are the youngest ones. These are of gray, granular limestone abounding in fossils related to those of the Table Head series of Newfoundland. This assemblage is of considerable interest because the fauna is known nowhere in the vicinity in an undisturbed sequence. Affinities with the highest Pogonip of Nevada are also apparent. Brachiopods from the youngest boulders are:

| | |
|---|--|
| <i>Acrotreta magna</i> Cooper | <i>Palaeoglossa mysticensis</i> Cooper |
| <i>Bimuria</i> ? <i>matutina</i> Cooper | <i>Paucicostella canadensis</i> Cooper |
| <i>Camerella breviplicata</i> Billings | <i>Pleurorthis convexa</i> Cooper |
| <i>C. polita</i> Billings | <i>P. corinna</i> (Billings) |
| <i>Hesperonomiella quebecensis</i> Cooper | <i>P. costellata</i> Cooper |
| <i>Idiostrophia costata</i> Ulrich and Cooper | <i>P. fascicostellata</i> Cooper |
| <i>I. perfecta</i> Ulrich and Cooper | <i>Ptychoglyptus</i> sp. 1 |
| <i>Idiostrophia</i> sp. 1 | <i>Rhysostrophia elliptica</i> Ulrich and Cooper |
| <i>Neostrophia subcostata</i> Ulrich and Cooper | <i>R. transversa</i> Ulrich and Cooper |

CHAMPLAIN VALLEY (EAST SIDE)

In west-central Vermont Cady (1945, pp. 548-554) described a series of Chazy rocks which are mostly poorly fossiliferous and of uncertain classification. The sequence from the top down is Middlebury limestone, Beldens formation, and Crown Point limestone. The last limestone is about 60 feet thick at Orwell, Vt., but thickens to 150 feet to the north. It is mostly gray, compact, massive limestone containing *Maclurites "magnus"* (LeSueur). The Beldens formation is buff-weathering dolomite interbedded with white marble. The formation contains the Weybridge member consisting of limestone with thin sandy streaks. The formation ranges up to 700 feet in thickness. Fossils are very rare. The Middlebury limestone, which attains a thickness of about 600 feet, is dark, blue-gray, partially dolomitic limestone with buff streaks.

In northwestern Vermont Kay (1945, p. 1171; 1947, p. 601) described a sequence consisting of the Beldens white, dense limestone 500 feet thick, followed by the Carman quartzite 60 to 125 feet thick. The latter is succeeded by the Youngman formation composed of argillaceous limestone grading upward into dark slate with interbedded limestone. The Youngman formation contains the brachiopod *Christiania* and the trilobite *Lonchodomas halli* (Billings).

Kay (1947, p. 601) suggested substitution of the name Burchards for the "Crown Point" formation "east of the Champlain thrust" because it is "structurally separated from the Crown Point limestone of the type locality and other outcrops in New York and is succeeded by the Beldens formation rather than by the Valcour limestone."

Correlation of formations on the east side of the Champlain Valley.—In a recent table of correlations Kay (1948, p. 1402) indicates equivalence of the Carman quartzite with the sandstone at the base of the Day Point formation in New York. The Youngman formation then becomes the equivalent of the Crown Point and Valcour limestones of New York. The Beldens and Burchards are not equivalent to any known formation under this arrangement. Inasmuch as these correlations are based on the lithology of two sandstones and not on fossils, they cannot be regarded as reliable. Based on what fossil evidence is available another arrangement is possible which is more in harmony with the known fossils.

Inasmuch as the Burchards was originally called Crown Point and does contain *Maclurites* according to Cady (1945, pp. 548-549) it is reasonable to correlate the Burchards with the Crown Point limestone. This places the Beldens as a possible equivalent of a sandstone at the top of the Valcour formation although no other evidence than position is now known. The Youngman formation with *Christiania*, by this arrangement would be thrown above the Chazy. This is in complete harmony with a similar situation in the Southern Appalachians where the *Christiania* beds of the Arline formation, probable equivalent of the Youngman, occur above Lenoir limestone with fossils that indicate correlation with the Crown Point-Valcour sequence.

LOWER MOHAWK AND UPPER HUDSON VALLEYS

Rocks deposited in the times embraced within this monograph are not well developed in this part of New York. The Lowville appears as remnants, about 27 feet thick at Inghams Mills and 6 feet at Amsterdam, according to Kay (1937, p. 254). It is not known at Glens Falls in the upper Hudson Valley but is present in the Champlain Valley as noted above. The Chaumont formation was not identified by Kay in the Lower Mohawk Valley but does appear in the Champlain Valley.

Amsterdam formation (Mohawk limestone of Conrad).—This formation is 11 feet thick in its type region but increases to 23 feet at Glens Falls. In the Saratoga Springs region Cushing and Ruedemann (1914, pp. 45-47) indicate an underground thickness of 40 to 60 feet. In the Saratoga region the limestone is somewhat thin bedded, crystalline, and fossiliferous. Kay (1937, p. 259) reports it as gray-black and heavy bedded in many sections in the Mohawk Valley. Few brachiopods have been listed from the formation:

Dalmanella rogata (Sardeson) = *Paucicrura rogata* (Sardeson)

Dinorthis pectinella (Emmons)

Rhynchotrema sp.

Strophomena trentonensis Winchell and Schuchert

Zygospira sp.

Correlation of Amsterdam formation.—Kay (1937, p. 259) shows that the Amsterdam limestone in the Crown Point section overlies the Chaumont formation (although the listed fossils are typical) and underlies the Isle la Motte limestone which is classified as equivalent to the upper Rockland. The Amsterdam is thus probably to be correlated with the lower part of the Rockland formation.

Isle la Motte formation.—This formation was named from the Champlain Valley and consists of black, gray-weathering limestone, medium textured and heavy bedded. It is about 10 or 11 feet thick at the type section. It occurs southward at many sections from Isle la Motte to Glens Falls in the upper Hudson Valley where it retains its heavy-bedded character but is considerably thicker, about 16 feet. *Strophomena* and *Zygospira* are listed as occurring in it at Glens Falls. The Isle la Motte limestone contains fossils that are associated with *Triplexia cuspidata* (Hall) elsewhere and therefore correlated by Kay (1937, p. 261) with the upper Rockland of the Ottawa Valley.

The Glens Falls limestone is overlain by the Larrabee formation which is regarded as equivalent to the Hull formation.

HUDSON VALLEY REGION (ALBANY TO POUGHKEEPSIE)

Rocks deposited in early Middle Ordovician time are not developed in the form of limestones in the region around Albany but the shelly facies is developed to a limited extent in the neighborhood of Poughkeepsie, N. Y. In Hudson Valley between Albany and Poughkeepsie the dark shales and slates of the Normanskill formation are developed. These abound in graptolites, but few brachiopods have been taken from them.

Normanskill formation.—This formation has been divided into two members: The lower one the Mount Merino chert and shale and the upper one called the Austin Glen grit and shale. The formation is estimated to be about 2,000 feet thick, but it has proved impossible to make accurate measurements. The bulk of the formation consists of shale, but grit, sandstone, chert, arkose, and conglomerate, ranking in the order named, are present.

Mount Merino member.—This member is mainly located on the east side of the Hudson and is characterized by considerable chert which, owing to its competent character, forms the backbone of some of the prominent hills in the Hudson Valley. The chert often contains numerous radiolaria (Ruedemann and Wilson, 1936). Black shales, especially those from the type section at Mount Merino, a quarry on the north side of the mountain, have produced more than 69 species of graptolites which make up the *Nemagraptus* zone of the Normanskill. These correlate with the lower part of the Athens formation of Tennessee, the Blockhouse formation of East Tennessee, the Columbiana formation of Alabama, the Paperville formation of Virginia, and other formations that contain this graptolite. The following brachiopods occur:

Leptobolus walcotti Ruedemann

Paterula amii Schuchert

Schizotreta papilliformis Ruedemann

Austin Glen member.—This member is composed of thick and thin beds of grit and shale, but the former predominates. The member is chiefly confined to the west side of the river. Fossils are rare in the Austin Glen member, but a few graptolites, eurypterids, and other fossils have been taken. Brachiopods are not reported. *Corynoides* and *Diplograptus* are two important graptolites of this member.

Overlying the Normanskill formation is an interesting conglomerate containing pebbles of several formations, and known as the Rysedorf conglomerate.

Rysedorf conglomerate.—This conglomerate is of varying thickness, from a few feet to 50 feet. Ruedemann (1930, p. 104) states "The Rysedorf conglomerate has a wide distribution within the Normanskill shale belt in the capital district; but it also extends into the Schuylerville quadrangle, where the writer has described it from the base of Bald Mountain ('14, p. 80); and it is found at Schodack Landing and may be identical with the Burden conglomerate described by Grabau from Becraft mountain near Hudson."

The pebbles of the Rysedorf conglomerate are of several kinds: gray limestone of early Cambrian age, black crystalline limestone with *Bolboporites*, said to be Chazy limestone (not necessarily so because *Bolboporites* is common in the lower part of the Edinburg formation in Virginia), Lowville limestone with *Tetradium cellulosum*, and black compact limestone with a prolific fauna related to the Chambersburg of Pennsylvania and the Edinburg formation of Virginia. This fauna is of considerable interest because it is impossible to derive it from any known source near Albany. The brachiopods of this suite of black limestone pebbles are:

Christiania trentonensis Ruedemann

Crania trentonensis Hall = *Petrocrania trentonensis* (Hall)

**Dalmanella testudinaria* (Dalman) = *Paucicrura* ?

Leptaena rhomboidalis Wilckens = *L. ordovica* Cooper

Orthis tricenaria Hall (sic) = *Hesperorthis* sp.

**Platystrophia biforata* (Schlotheim)

**Plectambonites sericeus* (Sowerby)

P. pisum Ruedemann = *Bilobia pisum* (Ruedemann)

Rafinesquina alternata (Emmons) = *Macrocoelia ruedemanni* (Salmon)

Siphonotreta minnesotensis Hall and Clarke

Ruedemann correlates this fauna with that of the Chambersburg limestone, but the part of that formation is not stated. *Christiania* occurs throughout the Edinburg formation which is a southwestward extension of part of the Chambersburg formation, but some of the other fossils occur more commonly in the Oranda formation just above the Edinburg such as *Leptaena*, *Rafinesquina*, and *Hesperorthis*. The possibility of these pebbles having been derived from the Youngman formation of Vermont should not be overlooked. This formation also contains *Christiania*, but the rest of the fauna is not known.

The presence of *Platystrophia* in these pebbles of the Rysedorf conglomerate is probably an error of identification. This genus has not yet been seen in the Chambersburg or Edinburg formations. It is suggested that *Oxoplectra* has been mistaken for *Platystrophia*. The Rysedorf conglomerate also reminds one

strongly of the Quebec City limestone which has Edinburg and possibly Youngman elements in it.

Another group of pebbles are composed of compact reddish-gray limestone and contain the following brachiopods:

Dalmanella testudinaria (Dalman)
Protozyga exigua Hall = *Cyclospira* ? *longa* Cooper
Rafinesquina alternata (Conrad)
Triplecia nucleus Hall

These are undoubtedly of Trenton age probably younger than the preceding.

A final group of pebbles are of gray crystalline limestone and are the commonest in the conglomerate. They abound in *Rafinesquina* and *Sowerbyella*. These contain also:

Dalmanella testudinaria (Dalman)
Dinorthis pectinella (Emmons)
Leptaena rhomboidalis (Wilckens) = *L. ordovicica* Cooper
Orthis tricenaria Conrad = *Hesperorthis tricenaria* (Conrad)
Parastrophia hemiplicata Hall = *Parastrophina hemiplicata* (Hall)
Plectambonites ruedemanni Raymond
P. pisum Ruedemann = *Bilobia pisum* (Ruedemann)
Plectorthis plicatella Hall
Protozyga exigua (Hall)
Rafinesquina alternata (Conrad)
R. deltoidea (Conrad)
Triplecia nucleus Hall
Zygospira recurvirostris (Hall)

Ruedemann dates this fauna as early Trenton. The presence of *Parastrophina* suggests Hull, and this is thus the youngest fauna in the conglomerate.

VICINITY OF POUGHKEEPSIE, N. Y.

Ordovician limestone appears in two northeast-southwest belts in the Poughkeepsie Quadrangle; the westernmost one is the Wappinger belt and the easternmost one is the Fishkill belt. Fair fossils have been produced from the Wappinger belt in the vicinity of Pleasant Valley and Rochdale, Poughkeepsie (15') Quadrangle. The Wappinger Creek belt is the only one mentioned here because fossils from the two localities mentioned above are recorded. At the railroad cut at Pleasant Valley *Tetradium cellulosum* is recorded from dove limestone (Knopf, 1927, p. 439). These are dated as Lowville, but it is conceivable that they actually belong to the Trenton. The dove beds are overlain by 65 feet of gray shale according to Knopf. The shales are followed by fine-grained, dark-gray, bluish-weathering limestone containing fossils. Another locality for fossils is on Wappinger Creek at Rochdale about 2½ miles southwest of Pleasant Valley. Brachiopods recorded from these two places are:

Dalmanella testudinaria = *Paucicrura* ?
Idiospira ? *warthini* Cooper
Lingula sp.
Nicolella angulata Cooper

Orthis pectinella = *Dinorthis pectinella* (Emmons)

O. tricenaria = *Hesperorthis tricenaria* (Conrad)

**Plectambonites sericea* = *Sowerbyella* sp.

Rafinesquina alternata = *Rafinesquina trentonensis* (Conrad)

These fossils suggest correlation with some part of the Rockland formation.

On the west bank of the Hudson (Gordon, 1911, p. 83) near Highland, during construction of the railroad, graptolites were found in the shales that cover a large portion of the west side of the Hudson in the Poughkeepsie Quadrangle. These graptolites contain *Nemagraptus* and belong to the lower Normanskill assemblage.

VICINITY OF NORTH CAMBRIDGE, N. Y.

A collection from three-quarters to a mile north of North Cambridge, N. Y., is of special interest. The rock is a coarsely granular, dark-gray limestone containing a few brachiopods, *Pleurothis* ? sp., *Bimuria* ? sp., *Onychoplecia*, *Sphenotreta*, and *Ptychoglyptus* sp. The specimens were taken from an area mapped as the Georgia slate. The collection has been variously identified from Ordovician to Silurian, the latter an obvious error.

The *Pleurothis* is a questionable reference for some of the specimens because they are plicate with the plicae overlain by costellae. No other orthid quite like it is known to the writer. The *Bimuria* ? is similar to the small *Bimurias* from the Pratt Ferry and Rich Valley formations and resembles *B. ? matutina* Cooper. The *Onychoplecia* is a large one and is most like *O. gracilis* (Raymond) from the Chazy group. The *Ptychoglyptus* is similar to *P. ? kindlei*. This comparison at once suggests Table Head or Mystic conglomerate as the probable relationship of these brachiopods. Doubt may be cast on this suggestion, however, because *Sphenotreta*, a Marmor and Porterfield genus, has not yet been taken in the Quebec or Newfoundland formations. It is possible, too, that these fossils actually belong to a part of the Chazy group hitherto undiscovered. Possibly they are related to the Youngman formation of Vermont which might be expected to have these genera.

Nothing is now known of the field relationships of the rocks from which this collection was taken. Possibly they came from boulders and are related to the Mystic and the Table Head, but more probably they belong in some part of the Chazy group or the early Porterfield stage Youngman formation.

4. THE APPALACHIANS (PENNSYLVANIA TO ALABAMA)

Many parts of the Appalachian Valley have been mapped in detail, and excellent maps have been published showing the extent of the formations in Alabama, Georgia, Tennessee, and Virginia. Yet with all this mapping and stratigraphic work very little has been done with the faunas. A few fossils were published, mostly without description, in reports on the geology of Alabama and Virginia, but similar reports on Tennessee are not provided with any helpful material on fossils. In fact only one paper on the brachiopods of the middle Ordovician of

the Appalachians has ever appeared (Willard and Raymond, 1928). The practice has been general of identifying Appalachian species with described forms from New York and Canada. These names have been applied without regard to facies, which has been, until recently, disregarded in the Appalachians. The vast stretch of elongated belts in the Valley thus afford almost virgin ground for the paleontologist. This monograph is testimony to this long neglect. The stratigraphy of the valley was not so long neglected, but it has been confused and misunderstood.

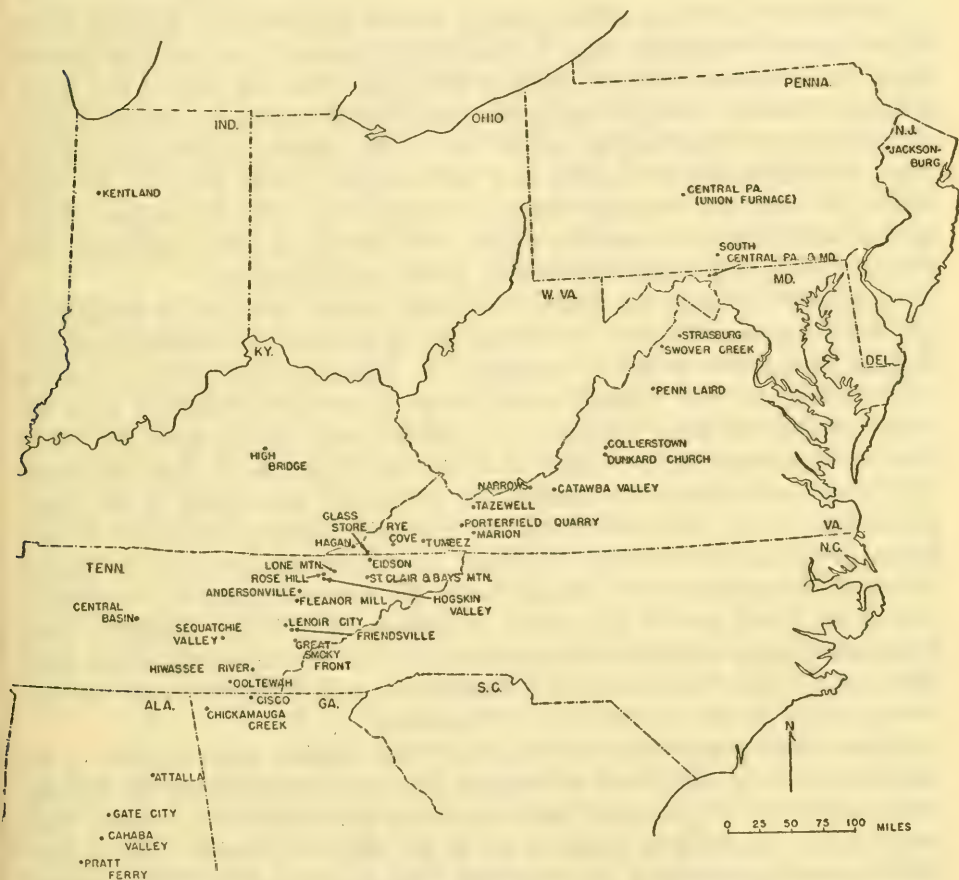


FIG. 1.—Map showing location of sections in the Appalachians.

For years the Appalachian stratigraphy has been explained on the theory that the Ordovician saw this area occupied by elongated seas separated by barriers. This view has now been displaced by the idea that the sediments of the Appalachian Valley were laid down in a normal geosyncline, and the long belts of varying types of sediment are best explained as facies developments. In this connection B. N. Cooper and I have prepared a detailed discussion of Appalachian stratigraphy based on facies, which is a collateral work to this monograph on the brachiopods and B. N. Cooper's study of Appalachian trilobites.

In the following portrayal of Appalachian stratigraphy I have arranged the formations alphabetically. To discuss them on a regional or structural basis would involve too much repetition. Consequently, formations proposed prior to 1936 are given with a list of brachiopod species and notes on correlation. Formations proposed after 1936, of which there are many, are described in more detail and the brachiopods listed.

FACIES IN THE APPALACHIANS

The idea of facies is as old as geology, but the application of the idea to the Appalachians is essentially new. Several of the pioneers in Appalachian geology knew and expressed ideas on shifts of lithologies from one part of the Appalachians to others. Keith, in particular, mentioned the passage of shales to limestones in certain instances, but at the turn of the century Appalachian stratigraphy was explained by elongate seas and barriers. Lately this idea has been challenged, and the classical theory of interlocking facies to explain Appalachian sedimentation is now the vogue. It is possible to divide the facies into the three basic rock types: Sandstones, shales, and limestones.

Sandstones.—Among the sandstones several facies types can be recognized: (1) The conglomerates often seen at the base of many of the formations but also in great masses such as that at Fincastle, Va. Generally these make up a minor portion of any section. Usually a basal conglomerate exists above the great unconformity on the Knox dolomite. (2) Coarse, clean quartz sands are not of common occurrence but are prominent in the Bays formation in Bays Mountain. (3) Shaly sandstones and mudstones are prominent, particularly in the upper part of the section. As exhibited by the Moccasin formation these may be red, green, or yellow and often mud cracked. The Bays and Moccasin formations are the great examples of the red-bed facies, but the same types are occasionally seen in the lower part of the section where they occur in the Surgener, Long Savannah, Attalla, or Blackford formations, but seldom compose the whole mass. Dirty sands, often ferruginous and occasionally with hematitic oolite, are exhibited by the Tellico and Red Knobs formations.

Shales.—The shales form rocks texturally intermediate between some of the limestones and the sandstones and usually contain combinations of the two opposite types. (1) A prominent shaly type is the shaly sandstone or sandy shale which covers hundreds of square miles as the Sevier formation. This is generally somewhat calcareous, and the fresh rock is a light blue. When leached and weathered, however, it is generally a dirty yellow. Fossils are rare in the Sevier, which generally is located in the easternmost belt of outcrop which is partly overridden by the Great Smoky Mountain mass. (2) Black shales are not prominent in the Appalachians except in a few areas such as that surrounding the city of Bristol in Virginia-Tennessee and in the Catawba Valley. The black shales generally contain graptolites in more or less abundance. The graptolite shales in the Appalachians, rather than being indicators of deep water, appear to be close shore deposits found in eastern belts or eastern belts that have been shoved to the west. The graptolite-bearing rocks of the easternmost belt of

East Tennessee interfingers with platy sandstones which themselves often contain fine graptolites. (3) Calcareous shales, often yellow-weathering, characterize the Hogskin member of the Lincolnshire formation and most of the Benbolt formation. These shales are reminiscent of the Sevier but do not contain much sand and are usually more calcareous than the Sevier. Furthermore, they are often characterized, particularly the Benbolt as exhibited in Raccoon Valley, by layers of limy cobbles.

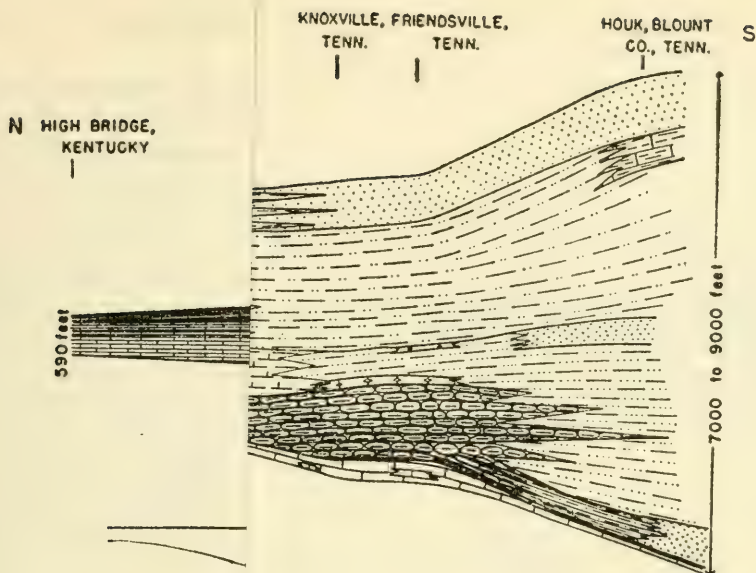
Limestones.—The western belts of the Appalachians are predominantly composed of limestone which interfingers with the finer clastics of the medial belts. (1) "Marble" is a term incorrectly applied to the calcarenites or coarse lime sands which are a prominent feature of some of the belts, particularly those in East Tennessee passing through Knoxville, but also prominent from Eidson southwest to Luttrell along Clinch Mountain. These masses have caused considerable difficulty in correlation because of their similarity of lithology and fauna regardless of position. The marbles are generally composed of echinodermal material, broken shells, and other organic debris. In some instances, as at Porterfield Quarry, McNutt Quarry, Tillson Mill, and a few other places, the calcarenites are associated with bioherms or "reefs" probably formed by bryozoans. A special type related to the calcarenites is the shell breccia which forms beds usually less than a foot, but occasionally several feet, thick. One or more beds of this type occur in the Witten formation and generally contain the peculiar *Cryptophragmus antiquatus*. This fossil is not confined to this lithology but is commonest in it. Many other types of fine or coarse detrital limestone are present in the Appalachians, but they do not generally form large masses. (2) Calcilitites, massive or thin bedded, are one of the commonest facies of the Appalachians and form most of the western belts. Indeed, this type of rock is so thick and so like the Lowville of New York that the New York name was applied to nearly the entire sequence along the Cumberland Front regardless of fossils which indicated otherwise. The name Lowville as used in the Appalachians was truly a facies term. The calcilitites form thick masses in the so-called Mosheim facies, which occurs at several levels in the Lenoir formation, and similar bodies occur at other levels. The fact that Mosheim-type calcilitites appeared frequently at the base of the Lenoir gave credence to the idea that it was a continuous sheet of rock rather than a facies. However, in one quadrangle in Virginia the Mosheim was mapped at three different levels, a clear indication that it is a facies and not a formation. (3) The black limestones of Virginia as typified by the Liberty Hall facies, and the Whitesburg formation of Tennessee are a special type of calcilitite. These are often heavy bedded, but may be the reverse, and are generally poorly fossiliferous. In some places they interdigitate with black shales, as in Catawba Valley. (4) The cobbly limestones, which are generally sandy or silty, are an eastern phase of limestone prominent in several belts in East Tennessee and also in the Lantz Mill facies of the Edinburg formation. The best example of this type is seen in the Arline formation and its lateral equivalent, the Athens formation. In East Tennessee this rock is often leached of its lime, when it appears to be a sandy shale, occasionally graptolitic, occa-

sionally wonderfully fossiliferous, as in the vicinity of Friendsville, Tenn. (5) A dolomitic facies is the final prominent carbonate rock facies. This type of rock consisting of light-gray dolomite or dolomitic limestone is prominent at the base of the Middle Ordovician in many belts. It is well displayed in the Blackford, Surgener, Pamela, Long Savannah, and other formations. These rocks, although at the base of the sequence, are quite clearly of different age across the geosyncline. This is probably true also of the Pamela formation of New York. The statement can be truly demonstrated in the Appalachians where the Blackford formation is equivalent to the Lenoir, but the Surgener formation, which is like the Blackford lithologically, contains marine fingers with fossils of the Lincolnshire (Hogskin member).

The facies diagrams.—Figures 2 and 3 represent ideal diagrams of the facies relationships roughly north and northeastward from the belt along the base of the Great Smoky Mountains to the exposures at High Bridge, Ky. The sequence would be essentially the same if it had been taken from the same beginning point to the Central Basin of Tennessee. The diagrams show a great wedge ranging in thickness from 7,000 to 9,000 feet on the east to about 600 feet on the west side. The eastern and thickest part of the wedge consists of clastics, coarse only in the extreme eastern and upper part of the column. The main mass of the clastics is sandy shale and sandstone, in some places limy and in others quite shaly. In the central portion of the diagrams the sequence has become shaly and limy with sand definitely subordinate except for the marbles which are actually a kind of coarse sand possibly formed by a continuously growing community of crinoids and cystids. The western and tapering edge of the wedge is composed of moderately thick and thin-bedded limestone, the so called "dove" limestone or Lowville facies. This facies evidently covered a great shelf area that occupied much of Tennessee and Kentucky in Ordovician days. It must be borne in mind that these diagrams are idealized and conventionalized and are not drawn to scale. It would be difficult to portray the facies intelligibly if the diagrams were to scale.

Comparison with Devonian facies of New York.—Perhaps the best exhibition of Paleozoic facies across a geosyncline is that exhibited by the great wedge of Middle Devonian sediments that extends from the Catskill Mountains to Lake Erie near Buffalo. The form of the Devonian wedge is like that of the one in Tennessee, but some differences are obvious. In the Devonian the red-bed facies occupies nearly the entire sequence in extreme eastern New York, and coarse conglomerates are present in the upper part of the sequence. In other words the Devonian facies are more developed as regards the clastics than the Tennessee wedge. It is suggested that this coarse clastic portion of the Ordovician facies is either overridden by the Great Smokies or was obliterated by mountain-making and accompanying contemporaneous igneous intrusions.

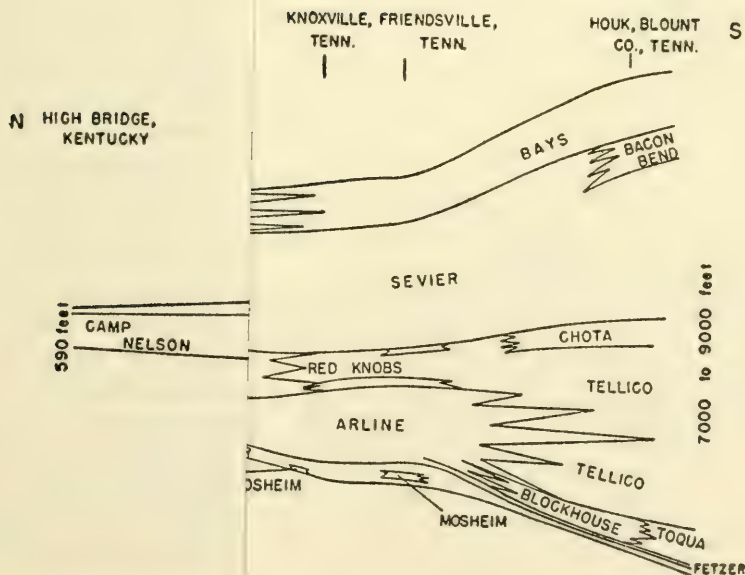
In the Devonian wedge a great development of black shales fingers with the sandy clastics to the east but occupies much of the section on the thinned edge of the wedge. This condition may be due to unusual paleogeographic conditions in the Devonian, such as a lowland to the north and west, that might have fur-



ORDOVICIAN W/
DATUM DRAWN
MARTINSBURG

TE

scale because of difficulties



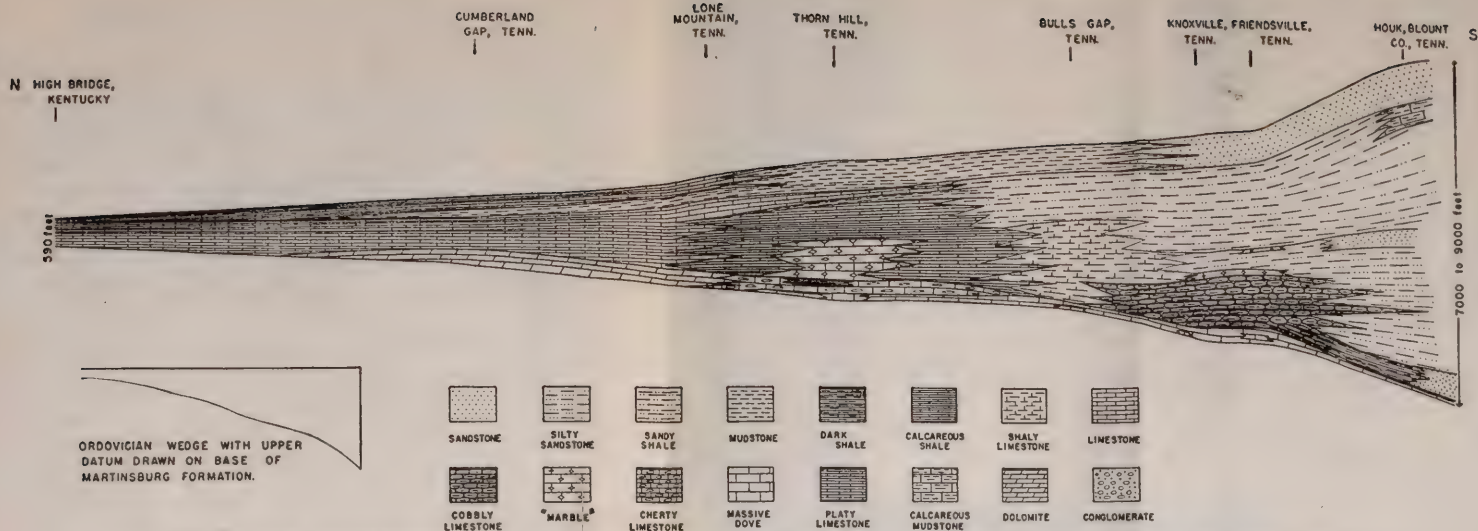


FIG. 2.—Diagram illustrating facies changes in east Tennessee and southwest Virginia from north to south. The diagram is not made to scale because of difficulties in drawing the facies shifts in the rapidly thickening wedge south of Friendsville.

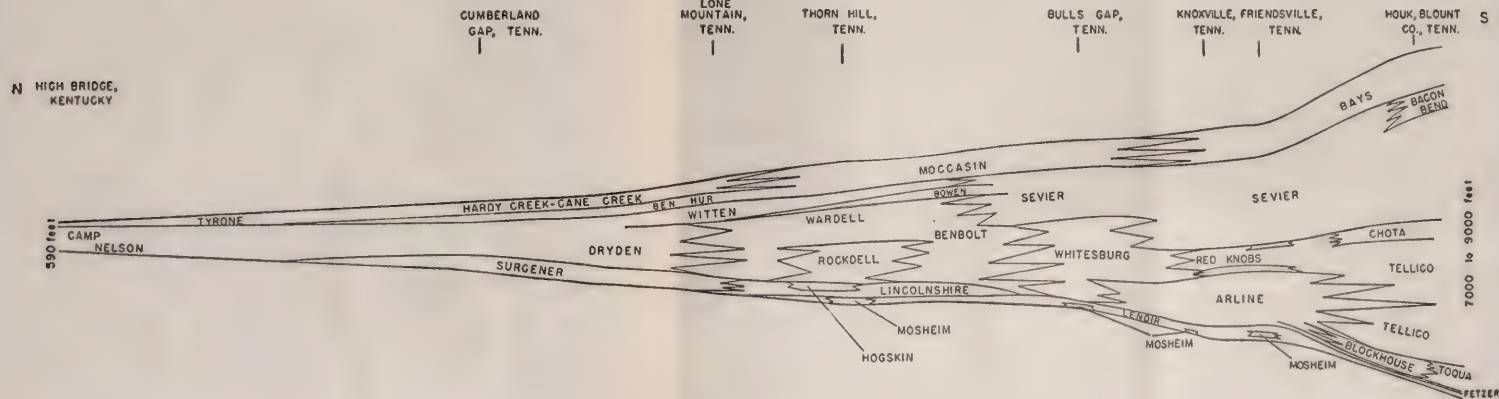


FIG. 3.—The same facies pattern with formation names.

nished the black shale. Nevertheless, black-shale development is less in the Ordovician wedge at the point the section was made. Had the section been taken through Bristol, Tennessee-Virginia, a greater development of the black shale would have been evident, but it is doubtful if it would have the enormous extent of that occurring in the Devonian. Furthermore, in the Devonian the black shale intervenes between the clastics and the limestones of the shelf facies. In the Ordovician wedge, on the other hand, cobbly limestones and limy shales with cobbles form an intermediate stage between the clastics and the limestones. The limestone facies is unlike that of the Devonian limestone in being composed of lime muds, whereas the corresponding facies in the Devonian contains more coarsely detrital limestone. Although the facies of the two periods are unlike in these minor respects, they are actually quite similar in their major aspects and show that a pattern existed in geosynclinal sedimentation.

The author (or authors) of each new formation name appears after the name.

Arline formation (B. N. Cooper and G. A. Cooper).—This name is taken for a limestone formation about 400 feet thick exposed almost in its entirety on both sides of the valley of a small stream tributary to Gallagher Creek, 2 miles southwest of the railroad switch at Arline on the Concord (T.V.A. 138-SW) and Louisville (T.V.A. 138-SE) Quadrangles, Tenn. The rock is mostly a cobbly-weathering, impure limestone containing considerable quantities of fine clastic material. It weathers by leaching of the lime to a yellow-brown soil containing numerous silicified fossils. The formation is underlain by dark, cherty limestone of the Lenoir formation and is overlain by shaly rock or calcarenite which is usually called "Holston marble" but is now the Red Knobs formation described herein as new.

This limestone is of restricted distribution in eastern Tennessee. It extends northeast from its type section to Knoxville where it forms a fairly wide belt in the south environs of the city and in the neighborhood of Shooks Gap. To the southwest it interfingers with the silty calcareous beds of the Athens formation. Fingers of the two types of sediment can be seen associated in the vicinity of Christiansburg, Sweetwater (T.V.A. 131-SW) Quadrangle, Tenn. Southwest of the latter place in the vicinity of Athens and southwest of Calhoun the type Athens formation in its upper part is cobbly limestone like the Arline, containing numerous trilobites and a few brachiopods having affinities with those of the Arline formation.

In the long and wide Ordovician belt along the west front of the Great Smoky Mountains fingers of this formation appear in the Tellico formation. These are especially well displayed along the Chapman Highway (Tennessee Highway 71) near Cusick, Walden Creek (T.V.A. 156-SW) Quadrangle. The Ordovician belt running from Philadelphia through Concord, just west of the Friendsville belt, does not reveal this formation, but a shale underlying the Farragut marble south of Philadelphia contains one of the leading guide fossils of the Arline formation (*Bimuria superba*). On the west side of the syncline north of Morristown, at St. Clair, about 300 feet of Arline is exposed on the east side of the road in a small quarry and adjacent area. Here the formation fingers

with black shale at the top, and calcarenite masses with *Ptychoglyptus* suggest the Effna formation of Virginia.

In Virginia, at Marion and vicinity, the characteristic fossils of the Arline formation occur in cobbly and shaly limestone 225 feet thick which occur above the *Maclurites* beds of the Lenoir and interfinger with black shale of the Rich Valley formation. The position of these beds and the occurrence of typical Arline fossils elsewhere in Virginia in the Botetourt formation, as in Catawba Valley, make it clear that these two formations are at least partial equivalents.

On the northeast side of the Saltville Thrust block at Porterfield Quarry, 5 miles northeast of Saltville, a thin remnant of the Arline formation occurs under the Effna calcarenites and reefs. The latter contain many elements of the Arline fauna, and the siliceous dark limestone underlying the Effna contains a suite of species related to, but not identical with, those of typical Arline.

The following brachiopods have been identified in the Arline formation of Tennessee (Knoxville to Friendsville):

| | |
|---|--|
| <i>Atelasma holstoni</i> (Hall and Clarke) ? | <i>O. blountensis</i> Cooper |
| <i>A. perfectum</i> Cooper | <i>O. friendsvillensis</i> Cooper |
| <i>Bimuria superba</i> Ulrich and Cooper | <i>O. tennesseensis</i> Cooper |
| <i>Camerella tennesseensis</i> Cooper | <i>Oxoplectia plicata</i> Cooper |
| <i>Christiania subquadrata</i> (Hall) | <i>Palaeostrophomena superba</i> Cooper |
| <i>Conotreta</i> ? <i>alta</i> Cooper | <i>Paterula perfecta</i> Cooper |
| <i>Cyrtototella virginicensis</i> Butts | <i>Paurorthis fasciculata</i> Cooper |
| <i>Dactylogonia geniculata</i> Ulrich and Cooper | <i>P. longa</i> Cooper |
| <i>D. obtusa</i> Cooper | <i>Perimecocoelia elliptica</i> Cooper |
| <i>Eremotoechia claudi</i> Cooper | <i>Phragmorthis buttsi</i> Cooper |
| <i>E. silicica</i> Cooper | <i>Platymena plana</i> Cooper |
| <i>Glyptorthis concinnula</i> Cooper | <i>Plectorthis australis</i> Cooper |
| <i>Isophragma biseptatum</i> Cooper | <i>P. compacta</i> Cooper |
| <i>I. extensum</i> Cooper | <i>Productorthis americana</i> Cooper |
| <i>I. subabbreviatum</i> Cooper | (Virginia, Marion quarry) |
| <i>Laticrura latibrachiata</i> Cooper | <i>Ptychopleurella globularis</i> Cooper |
| <i>Leptellina tennesseensis</i> Ulrich and Cooper | <i>Rhipidomena</i> sp. 1 |
| <i>Lingulasma matutinum</i> Cooper | <i>Schizambon irregulare</i> Cooper |
| <i>Lingulella</i> sp. 4 | <i>S. subradiatum</i> Cooper |
| <i>Lingulella</i> sp. 5 | <i>Siphonotreta americana</i> Cooper |
| <i>Macrocoelia obesa</i> Cooper | <i>Sowerbyella varicostellata</i> Cooper |
| <i>Multicostella planosulcata</i> Cooper | <i>Taphrorthis emarginata</i> Cooper |
| <i>M. plena</i> Cooper | <i>Titanambonites amplus</i> (Raymond) |
| <i>M. saffordi</i> (Hall and Clarke) ? | <i>Valcourea brevicarinata</i> Cooper |
| <i>Opikina glabella</i> Cooper | <i>Valcourea</i> sp. 4 |
| <i>Orthambonites angulatus</i> Cooper | |

The thinned Arline at Porterfield Quarry in Virginia has yielded:

| |
|---|
| <i>Leptellina transversa</i> Cooper |
| <i>Opikina matutina</i> Cooper |
| <i>Palaeostrophomena subtransversa</i> Cooper |
| <i>Sowerbyella silicica</i> Cooper |
| <i>S. silicica nana</i> Cooper |
| <i>Valcourea semicarinata</i> Cooper |

Correlation of Arline formation.—The most important elements of the brachiopod faunules listed above are: *Bimuria*, *Christiania*, *Eremotoecchia*, *Isophragma*, *Palaeostrophomena*, *Phragmorthis*, *Platymena*, and *Titanambonites*. These have a wide geographic distribution, and some of them have a fair stratigraphic distribution. The Little Oak fauna of Alabama is very similar to that of the Arline and contains nearly all the genera and many species that are very close and a few identical ones. The Pratt Ferry fauna is related to the Arline and is probably a part of the Little Oak. The Botetourt formation of Virginia, particularly in the Catawba Valley and on the north side of Marion, contains many of the same species. This is true also of the Effna formation which appears to be a reefy development of the Arline. Farther afield the lower Edinburg (*Cyrtonotella* zone) of northern Virginia and the Shippensburg formation (Pinesburg member) of Maryland and southern Pennsylvania contain many of the Arline genera together with some of its species. The Arline and its correlates thus extend from Alabama to south-central Pennsylvania.

It should be mentioned here that the fauna of the Benbolt formation contains numerous elements of the Arline fauna and is indeed the last manifestation of that fauna, except for its return in a modified form in the Oranda formation. The Tellico formation of East Tennessee for many hundreds of feet contains fossils in tongues of limestone or sandstone that are undoubtedly extensions of the Arline. It should also be mentioned that the Arline-Little Oak faunas and their correlates are closely related to the Stinchar-Balclatchie assemblage of the Girvan district of Scotland. The Oranda of Virginia is the final manifestation of the Arline fauna but is modified by numerous Trenton elements such as *Cryptolithus*, *Rafinesquina*, *Calymene*, *Strophomena*, and *Reuschella*. Elements of the Arline fauna such as *Christiania* can be found all through the Edinburg formation of northern Virginia.

Athens formation.—The Athens shale was described by Hayes (1894b) as follows:

East of the Tennessee River the upper part of the Chickamauga limestone is replaced by shales from 300 to 500 feet in thickness. Eastward beyond the edge of this sheet this formation increases to several thousand feet in thickness, where the strata represent the rapid and variable accumulation of sediment near the shore.

The formation takes its name from Athens, Tennessee, on the Cleveland sheet.

In the description of the Athens "shale" on the Cleveland sheet the rock is said to be "in some places sandy, but generally calcareous, dark-blue when fresh, but weathering yellow." Examination of the type section in the railroad cut north of Athens shows the type Athens to have only a small amount of shale near the base. The formation is mostly a silty or sandy, cobbly limestone that weathers to a yellow sandy, shaly rock. The disintegrated rock evidently led to the conception that the Athens is a shale. As now applied, the name Athens is most used for black graptolite shale, completely unlike anything in the type section. It is here proposed that the name "Athens" be restricted to the type region where the formation proves to be a facies of the Arline formation.

At the type section of the Athens the formation rests on a thin tongue of the

"Chickamauga" limestone, identified in this belt as Lenoir limestone, overlain by a thin bed of impure limestone, the Fetzer tongue of the Arline formation abounding in *Christiania*. The lower bed, like the Athens above it, is often leached of its lime, as it is $2\frac{1}{2}$ miles southeast of Riceville. The lower shaly-fracturing part of the Athens in the type section is succeeded by cobbly-weathering, silty limestone abounding in trilobites.

Essentially the same sequence is shown in the superb section along the road running parallel to the Hiwassee River, 2 to 3 miles southeast of Charleston. Here about 170 feet of silty shale overlies sandy, oolitic beds containing calcareous lenses and *Christiania*. These sandy shales contain graptolites and are overlain by calcareo-arenaceous beds strongly suggesting Sevier lithology and grading into cobbly-weathering limestone. The cobbly beds abound in trilobites, particularly the genus *Lonchodomas*. These beds are overlain by shaly limestone and marble containing many fossils. The upper cobbly beds yielded few fossils besides the trilobite mentioned, but poor specimens of *Christiania* and *Platymena* occur very close to the top of the section.

Traced to the northeast from Athens to Friendsville, the Athens formation loses its shaly character in the lower part and becomes more limy. With the advent of the line, fossils of the *Christiania* fauna become increasingly abundant. This shift of facies is well exhibited in the neighborhood of Christiansburg on the Sweetwater (T.V.A. 131-SW) Quadrangle. Farther north, at Friendsville, no trace of the Athens has yet been identified. Southeast of Sweetwater along Route 68 the cobbly zone of the Athens is well exposed and contains elements of the *Christiania* fauna of the Arline limestone. Thus, followed northeast along the strike from Athens, the Athens formation passes from cobbly and shaly beds to wholly limestone of the Arline formation. Outside of this belt rocks called Athens have different characters, black shale or black limestone, and actually generally represent only a part of the type Athens to the east but include more than that formation where the so-called Athens overlies the Arline formation. To these manifestations of the Athens or post-Athens outside of the Athens belt other names are here applied.

Correlation and fossils of Athens formation.—In the vicinity of Athens and as far south as the Hiwassee River the leached rock at the base of the Athens yields an interesting fauna of brachiopods. Those taken from this part of the Athens and the rest of the formation follow:

Apatomorpha pulchella (Raymond)
Ateleasma dorsoconvexum Cooper
Christiania subquadrata Hall
Glyptorthis sp. 5
Isophragma ricevillensis Cooper
Leptellina subcarinata Cooper

L. tennesseensis Ulrich and Cooper
Orthambonites rotundiformis Cooper
Paurorthis sp. 1
Schizotreta posteroconvexa Cooper
Titanambonites amplius (Raymond)
T. medius Cooper

Athens shale of Georgia.—This is a thinned representative of the Paperville formation of Cooper and Cooper (see below).

Athens shale of Alabama.—This is generally a papery black shale, in places abounding in graptolites. It is here termed by Cooper and Cooper the Colum-

biana formation and is regarded as a lateral facies of the Little Oak formation (see below).

Athens shale of Virginia.—This has been renamed in the Bristol area and Catawba Valley the Paperville formation by Cooper and Cooper. The graptolite shales in the Saltville thrust block are called Rich Valley formation by Cooper and Cooper (see below).

Athens limestone.—The ash-weathering black limestones of Virginia, which were called Athens by Butts, were regarded as a facies of the Edinburg formation for which Campbell's (1905) name "Liberty Hall" was revived by Cooper and Cooper (1946).

Attalla formation.—A coarse conglomerate at the base of the Chickamauga limestone in Birmingham Valley, Alabama (Butts, 1911, p. 37). The conglomerate is patchy in occurrence. This conglomerate, together with red and green shales at the base of the Chickamauga which the writer includes in the name Attalla, is suggestive of the Blackford lithology of Tennessee and Virginia but obviously deposited at a different time than the Blackford.

Only one brachiopod, *Lingulella fostermontensis* (Butts), has been taken from the shaly phase of the Attalla on the Birmingham Quadrangle.

Bacon Bend member of Sevier formation.—R. B. Neuman (1956, p. 162) proposed this name for interbedded gray and red calcareous shale and siltstone with some non-red beds possessing submarine slump structures. The type section is near Bacon Bend on the Tennessee River, Vonore (T.V.A. 139-SW) Quadrangle. The formation contains a few poorly preserved fossils:

Pionodema camerata Cooper

Rostricellula sp.

Zygospira sp.

Bays formation.—This name was proposed by Keith (1895, p. 4) for the great succession of red beds in Bays Mountain, northeast Tennessee. These red beds contain a considerable thickness of clean white quartzite. The Bays is variable in thickness but in places is many hundreds of feet thick. It is also identified in the Catawba Valley belt.

Brachiopods taken from the Bays are:

Ectenoglossa ? *rubra* Cooper

Pseudolingula luttrellensis Cooper

Correlation of Bays formation.—Fossils taken just under the base of the Bays formation in Tallassee Quadrangle at Fourmile Church are identified as a new species of *Pionodema* (*P. camerata*). This suggests that the Bays rests on rocks equivalent to part of the Witten formation. The same conclusion was reached from fossils collected under the Bays in Bays Mountain at Guthrie Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle, where *Zygospira* occurs. The earliest known appearance of this fossil elsewhere in the Appalachians is in the Witten formation.

Benbolt formation.—This formation was described by B. N. Cooper and C. E. Prouty (1943, p. 868), and its type section was designated as exposures

1½ miles south of Benbolt west of the Tazewell County Farm. At its type section the formation consists of two members both composed of limestone, the lower one called Shannondale limestone and the upper one known as the Burkes Garden member. These member names have not been used far outside the confines of the county. The Benbolt is separated from the overlying Wardell formation by the Gratton formation. The Benbolt is characterized by numerous distinctive fossils that are confined to this level as far as known. These fossils make it possible to identify the Benbolt interval in belts in which the lithology is quite different from that of the type section. The Benbolt, as indicated by its distinctive fossils, is widely distributed in southwestern Virginia and northeastern Tennessee. Traces of the fossils occur as far north as southern Pennsylvania and as far south as Georgia.

Benbolt formation in Virginia.—In the Cumberland Front sequence in extreme southwest Virginia the Benbolt is not typically developed, but a probably partial equivalent is the Hurricane Bridge limestone. At the north end of the St. Clair fault block the Benbolt is typically developed and is composed chiefly of limestone as described for the type section. To the southwest the Benbolt becomes a soft shale and cobbly limestone abounding in exceptionally well preserved fossils. The Clinch Mountain belt contains an excellent sequence of this formation which here is a soft gray shale. In some of these belts the Gratton limestone is absent, with the result that it is usually difficult to draw a satisfactory boundary between the Benbolt and Wardell formations. The two combined formations are then called Dryden formation, but it is usually possible to recognize Wardell elements in the upper part and Benbolt species in the lower part.

In the Saltville fault block the interval of the Benbolt plus part of the Ward Cove is represented by black limestone, here called Chatham Hill formation, but a sufficient number of Benbolt fossils is preserved in these dark limestones to distinguish the presence of the formation. In west-central and northern Virginia the Middle Ordovician sequence is dominated by the Edinburg formation. At the base of this formation is a zone characterized by cobbly and black limestone containing Benbolt fossils intermingled with those characteristic of the Arline formation. For example, *Dinorthis transversa* is present in the *Cyrtontella* and *Nidulites* zones of the Edinburg formation and in the lower part of the Shippensburg formation (Pinesburg member) of Pennsylvania and Maryland, which is a partial equivalent of the Edinburg. The same *Dinorthis* together with characteristic fossils of the Arline fauna betray the presence of Benbolt equivalents in the dark limestones exposed in the Eagle Rock (15') Quadrangle.

Benbolt formation in Tennessee.—The extension of the Clinch Mountain belt into Tennessee exposes the Benbolt formation in its shaly facies for many miles. It is also well displayed as a shale, often with limy cobbles and thin layers of limestone in Beaver, Raccoon, and Hogskin Valleys. In the vicinity of Lone Mountain, shale at the interval of the Benbolt appears to contain a fauna with Wardell as well as Benbolt faunal elements intermingled to such an extent that the term Benbolt is inapplicable and Dryden is used as in Virginia. In the Clinton belt the formation has lost its individuality.

In the Knoxville region and to the south Benbolt faunal elements appear in the lower part of the Ottosee (=Sevier) shale. Benbolt fossils appear in the upper part of the Sevier along the west front of the Great Smoky Mountains in a sandstone (No. 5) above the Chota sandstone of Neuman.

In northwestern Georgia thin-bedded limestone separated by layers of shale occurs on U. S. Highway 27 just north of Chickamauga Creek. *Mimella* and a few other species here are suggestive of the Benbolt, but the sequence has been placed tentatively in the Ridley formation.

Brachiopods are abundant in most localities of the Benbolt. The greatest variety occurs in the lower beds near the contact with the subjacent formation. Here occur genera and species reminiscent of the Arline fauna. In the higher shales specimens are usually more scattered and some appear in the limy cobbles that often make up a substantial part of the formation. Brachiopods are:

Acanthocrania grandis Cooper

Atelasma planum Cooper

Bellimurina sp. 1

Camerella sp. 1

Chaulistomella brevis (Willard)

C. elongata (Willard)

Cyrtototella crassicostella

(Schuchert and Cooper)

C. fasciculata Cooper

C. subquadrata Cooper

Dactylogonia sp. 1

Dactylogonia sp. 3

Dactylogonia sp. 6

Dinorthis interstriata Willard

D. transversa Willard

D. transversoides Cooper

Eremotrema biconvexa Cooper

Fascifera convexa Cooper

F. stonensis (Safford)

Glyptorthis rara Cooper

G. uniformis Cooper

G. uniplicata Cooper

Hesperorthis multicostata Cooper

Isophragma biseptatum Cooper

Leptellina platys Cooper

L. pulchra Cooper

L. sublamellosa Cooper

Lingulella virginensis Cooper

Lingulella sp. 11

Macrocoelia magna (Butts)

M. rotunda Cooper

Mimella globosa (Willard)

M. sulcata Cooper

Murinella cancellata Cooper ?

M. muralis Cooper

M. plana Cooper

Oligorhynchia bifurcata Cooper

Oligorhynchia sp.

Opikina parvula Cooper

Opikina pulchella Cooper

Opikina sp. 1

Orthambonites parvicrassicosatus Cooper

Oxoplectia multicostellata Cooper

O. parva Cooper

Pachyglossa pachydermata Cooper

Palaeostrophomena resupinata Cooper

Paurorthis ponderosa Cooper

Perimecoelia semicostata Cooper

Pionodema crassipunctata Cooper

Plectocamera aseptata Cooper

P. sulcata Cooper

Plectoglossa sp. 1

Plectorthis tenuis Cooper

Protozyga uniplicata Cooper

Ptychopleurella uniplicata Cooper

Rhipidomena tennesseensis (Willard)

Rostricellula rostrata Ulrich and Cooper

Schizambon macrothyris Cooper

Skenidioides mediocostatus Cooper

Sowerbyella compacta Cooper

Strophomena anomala Cooper

Faunal discussion and correlation of Benbolt formation.—The Benbolt fauna is essentially a transitional assemblage because it contains elements of the Arline and equivalent faunas and at the same time elements of the overlying Wardell assemblage. The basal beds of the Benbolt are the parts that contain most of the elements related to the Arline fauna such as *Palaeostrophomena*, *Cyrtono-*

tella, *Isophragma*, *Paurorthis*, *Perimecocoelia*, and *Rhipidomena*. This is the last appearance of *Cyrtotonotella*, *Isophragma*, *Perimecocoelia*, and *Rhipidomena*. Wardell elements are: *Fascifera*, *Murinella*, *Pionodema*, *Rostricellula*. The Benbolt is not the earliest appearance of any of the genera just mentioned except *Pionodema*, but these genera are abundant in the Wardell and fairly characteristic of it, except for *Pionodema*. The assemblage that appears in the Arline is thus terminated in the Benbolt, and thereafter a marked faunal change takes place. After the Benbolt the faunas contain elements of the Trenton such as *Strophomena*, *Doleroides*, *Zygospira*, and *Pionodema*.

Benner limestone.—This formation (Kay, 1944, p. 15) is composed of well-bedded limestone 14 to 190 feet in thickness. It is present throughout central Pennsylvania and southeastward to the western belts of Cumberland Valley. The type section is at Union Furnace although the name is from a township in Centre County. The formation is composed of two members; the lower one is the Snyder limestone and the upper is the Stover limestone. These two names should be consulted for details.

Hallina lirata Cooper is recorded from the undivided formation. The Benner is regarded as a correlate of the Witten formation of Virginia and Tennessee.

Ben Hur formation.—This formation was proposed by Miller and Brosge (1950) and consists of yellowish-gray limestone and yellow to buff, drab mudstone about 180 feet in thickness. The middle portion of the formation is marked by a few limy layers with *Camarocladia*. This formation was named for an exposure in the L. and N. RR. cut west of Ben Hur, Ben Hur (T.V.A. 170-NE) Quadrangle, Va. The following brachiopods are known:

Pionodema minuscula (Willard)

Strophomena sp.

Zygospira sp.

Blackford formation.—Butts proposed this name for a series of conglomerates, red beds, gray shales, dolomites, and chert beds which overlie the Knox dolomite at Blackford, Russell County, Va. These beds were overlain by a vaughanitic limestone or calcilutite identified by Butts as Mosheim limestone. The Blackford was originally defined as a facies of the Murfreesboro formation which was thought to overlie the Knox and underlie the Mosheim.

Subsequent work on the Blackford indicates that it does not correlate with the Murfreesboro limestone of the Central Basin of Tennessee. Cooper and Prouty (1943, p. 862) therefore graduated Butts' term to their Clifffield formation where it formed the lowest member. The member as described by Cooper and Prouty is a composite containing separable units. The Blackford therefore has undergone further revision. The upper "blocky chert" was separated as the Elway formation (B. N. Cooper, 1945b, p. 42). In some areas the Blackford contains calcarenites with *Rostricellula* that are recognizable as, and referable to, the Lenoir formation. These, too, have been named. Blackford has thus become a name of little use. It may be applied to basal shales, dolomites, and conglomerates, but these are often demonstrably of different age in different belts. The name is therefore of little use in Appalachian stratigraphy in any

other sense than a facies term except in its type belt. (See Elway and Tumbes for faunal lists.)

The supposed equivalence of Murfreesboro and Blackford is explained under the Chickamauga limestone. The varying age of the Appalachian Mosheim fixed the ages of underlying beds. It takes no imagination in examining faunal lists said to be from the Murfreesboro of the Appalachians to understand that the Blackford is not the same from place to place. It is an odd fact that no uniformity of faunas has been detected in this member. Few brachiopods have been taken from the restricted Blackford:

Camerella sp. 2

Obolus sp. 2

Blockhouse formation (R. B. Neuman (1956, p. 148).—This name is proposed for dark-gray to black calcareous shale containing graptolites, exposed in the belt along the base of the Great Smoky Mountains in East Tennessee and best seen on the Blockhouse (T.V.A. 148-NW) Quadrangle where the type section is located. The formation ranges from 175 to 500 feet in thickness. It correlates with part of the Athens formation, probably the lower part. The Blockhouse shale rests on the cobbly Fetzer, a tongue of the Arline formation. Few brachiopods have been taken:

Paurorthis catawbensis (Butts)

Botetourt formation.—Cooper and Cooper (1946, p. 80) proposed this name as a member of the Edinburg formation for brown-weathering, impure granular limestone overlying the Lincolnshire formation. The type section is on the hillside $\frac{1}{4}$ mile south of Dunkard Church and 6.9 miles S. 80° W. of Natural Bridge, Va. This member, now made a formation, is prominent and easy to identify in many localities in central Virginia, but it was identified with some difficulty in northern Virginia, although many species of the member occur in granular limestone at the base of the *Cyrtototella* zone. An excellent development may be examined in Catawba Valley northeast of Blacksburg where it underlies or fingers with calcarenites of the Effna formation. The member is here given formation rank.

The Botetourt can be recognized in parts of Tennessee as at the type section of the Whitesburg of Ulrich. At this place it overlies the Lenoir and occurs at the base of Ulrich's Whitesburg formation. It is identifiable at Mosheim and at Albany, Tenn.

At Edinburg Dam section about 1 mile below Edinburg and at Tumbling Run $1\frac{1}{2}$ miles southwest of Strasburg, Va., dark thin-bedded limestone occurs between granular beds thought to be Botetourt and the cherty Lincolnshire. These contain the trilobite *Cybelloides* and brachiopods such as *Cristiferia* that are clearly of post-Lincolnshire affinities. These beds are here placed in the Botetourt formation.

The following brachiopods have been taken from the Botetourt formation:

Acanthambonia virginienensis Cooper

Ateleasma sp. 2

Bilobia virginienensis Cooper

Bimuria immatura Cooper

B. superba Ulrich and Cooper
Camerella minuta Cooper
Christiania subquadrata (Hall)
Conotreta ? *altirostra* Cooper
C. multisinuata Cooper
Cyrtotonotella grandistriata (Willard)
C. virginensis Butts
Cyrtotonotella sp.
Dactylogonia transversa Cooper
Dactylogonia sp. 2
Doleroides ? *ponderosus* Cooper
Elliptoglossa ovalis (Bassler)
Eoplectodonta ? *dubia* Cooper
Glossella sp. 1
Glyptorthis equiconvexa Cooper
Hesperorthis ? *costellata* Cooper
Hesperorthis sp. 1
Isophragma biseptatum Cooper
Kullervo punctata Cooper
Leptellina pulchra Cooper

L. tennesseensis Ulrich and Cooper
Limbinurina brevilibata Cooper
Multicostella bursa (Raymond)
Öpikina ? *dubia* Cooper
Orthambonites brachiophorus Cooper
O. parvicrassicostratus Cooper
O. tennesseensis Cooper
Oxoplectia holstonensis Willard
Pachyglossa pachydermata Cooper
Palaeostrophomena angulata Cooper
P. ? *rugosa* Cooper
Paterula perfecta Cooper
Paurorthis catawbensis Butts
Perimecocoelia semicostata Cooper
Productorthis americana Cooper
Ptychoglyptus virginensis Willard
Scaphorthis perplexa Cooper
Schizambon cuneatum Willard
Schizotreta shuleri (Willard)
Taphrorthis peculiaris Cooper

Correlation of Botetourt formation.—The fauna of the Botetourt formation is clearly related to that of the Arline and Effna formations. *Ptychoglyptus*, *Kullervo*, *Leptellina pulchra*, *Oxoplectia holstonensis*, and *Perimecocoelia* emphasize this correlation.

Bowen formation.—This formation was named by Cooper and Prouty (1943, p. 876) from Bowen Cove at the northwest base of Short Mountain, Tazewell County, Va. It consists of about 60 feet of brown sandstone and red mudrock often exquisitely mudcracked lying between the Wardell and Witten formations. The Bowen has been identified extensively in southwestern Virginia and parts of northeastern Tennessee. The formation has not yet produced any brachiopods.

The Bowen formation was thought by Butts to be the initial stage of the Moccasin formation, but Cooper and Prouty (1943, p. 877) show that Campbell did not include this red bed in his definition of the Moccasin formation. Witten and Wardell may be difficult to separate where the Bowen is absent.

Burkes Garden member of Benholt formation.—This member was named by Cooper and Prouty (1943, p. 869) from Burkes Garden Creek south of Gose Mills, Tazewell County, Va. The rock is mostly argillaceous, crinoidal, and bryozoan-bearing limestone. The lower beds abound in ramose bryozoans. The member is variable in thickness, ranging from 50 to approximately 100 feet. In Thompson Valley and Burkes Garden cross-bedded calcarenites are present, attaining about 100 feet in thickness in the latter place. The member is absent in the Clinch and Bluestone valleys.

Brachiopods listed from the member (Cooper and Prouty, 1943) are:

Campylorthis sp. = *Chaulistomella* sp.
Dinorthis cf. *D. quadriplicata* Willard
D. transversa Willard

**Glyptorthis bellarugosa* (Conrad)

"*Leptaena*" aff. *L. palustris* Willard = *Dactylogonia*

Mimella superba Butts

Opikina "minnesotensis" (N. H. Winchell)

Paurorthis sp.

Planidorsa sp. = *Cyrtonotella* sp.

Ptychoglyptus sp.

"*Rafinesquina*" cf. *R. obsoleta* Butts

Sowerbyella aff. *S. aequistriata* Willard

Strophomena tennesseensis Willard = *Rhipidomena tennesseensis* (Willard)

Cane Creek formation (B. N. Cooper and G. A. Cooper).—Mostly thin-bedded gray to dove limestone weathering to light gray, the layers of limestone often separated by thin shale partings. The sequence contains several bentonites, especially two thick ones near the top. One of these, 3 feet thick, is about 2 feet below the top, but the other 2 to 8 feet thick occurs 42 feet below the top. A bentonite about 1 foot thick occurs at the base of the section. The entire formation is about 150 feet thick. A greenish mudstone bed 30 feet thick occurs 13 feet from the base. The type section is along the L. and N. RR. east of Cane Creek and approximately $\frac{1}{2}$ mile west along the railroad from Ben Hur Station, Ben Hur (T.V.A. 170-NE) Quadrangle, Lee County, Va.

Brachiopods are fairly common in the upper part of the formation between the two thick bentonites. The following species occur:

Chaulistomella lebanonensis Cooper

Doleroides tennesseensis Cooper

Opikina sp.

Pionodema sulcata Cooper

Strophomena sp.

Zygospira sp.

Carlim limestone.—The discriminating work of Kay (1944, p. 20) has shown this formation of Butts (1918, p. 526) to be a composite one. Kay states that "the Carlim limestone is the upper Loysburg plus the Hatter in its type locality." In his original publication Butts also named the Lemont member of the Carlim formation which formed the top. The Carlim formation was said to overlie the Bellefonte dolomite and underlie the Lowville limestone. Its position inferior to the Lowville limestone led to assigning a Chazyan age to the Carlim limestone.

The fact that the Carlim limestone consists of distinct units is not the only difficulty in understanding it. The Lemont member at the top is usually the Hostler of Kay rather than the type Lemont which occurs in a position much higher (Nealmont) than the Carlim. Occurrence of *Maclurites* in the Lemont and Hostler and the insistence that this fossil must be Chazyan added to the confusion.

Published lists of fossils from the Carlim limestone and Butts' collections in the National Museum indicate that the Carlim is actually not Chazyan at all. In view of the confusion all around it seems best to drop Carlim in favor of the units recommended by Kay: Loysburg and Hatter. Faunal lists are cited under these names.

Carters formation in the Appalachians.—(See Chickamauga limestone.)

Centre Hall member of Nealmont formation.—The original spelling of this name by Field (1919, p. 417) was incorrect. Kay altered the spelling to conform, as above, with that of the county and village. Although Field proposed the name as a formation, Kay has lowered its rank to one of the members of his Nealmont formation. The Centre Hall member is distinguished from the underlying Oak Hall member by its thinner-bedded and more shaly character. A fairly imposing list of brachiopods has been identified from the member, but some of the identifications seem incorrect. The member has been placed in the early Trenton and correlated with part of the Rockland formation. The list of brachiopods does not wholly support this contention. *Valcourea* has not been seen this high elsewhere, nor has *Parastrophina hemiplicata* been seen below the Oranda. The identification of *Sowerbyella punctostriata* is probably incorrect. The brachiopods identified are:

| | |
|---|---|
| <i>Ancistrorhyncha</i> sp. | <i>Ö. wagneri</i> (Okulitch) |
| * <i>Dolerooides pervetus</i> (Conrad) | <i>Parastrophina hemiplicata</i> (Hall) |
| * <i>Glassia</i> sp. | <i>Rhynchotrema</i> sp. |
| * <i>Glyptorthis</i> sp. cf. <i>G. bellarugosa</i> (Conrad) | * <i>Sowerbyella punctostriata</i> (Mather) |
| <i>Hesperorthis tricenaria</i> (Conrad) | <i>Strophomena</i> sp. cf. <i>S. filitexta</i> (Hall) |
| * <i>Leptaena</i> sp. cf. <i>L. charlottae</i> Winchell and Schuchert = <i>Limbimurina</i> | <i>Strophomena</i> sp. |
| * <i>Öpikina iniquassa</i> (Sardeson) | * <i>Valcourea</i> sp. cf. <i>V. loricula</i> (Hall) |
| <i>Ö. minnesotensis</i> (N. H. Winchell) | <i>Zygospira recurvirostris</i> (Hall) |

Chambersburg formation.—This, like some other thick formations of the Appalachians, has been revised and reorganized to such an extent that the name, when used at all, really takes the form of a group term. This is now especially true of the Chambersburg formation. It was first revised by Butts, then by Cooper and Cooper, and finally by Craig, who completely split up the old formation and did not use the name Chambersburg.

As originally defined the formation included about 150 feet of calcilitite at the base which was correlated to the Lowville formation. The Chambersburg above this basal part was thought to belong to the Black River. Butts (1940b, p. 195) excluded the Lowville part from the formation. In 1946 Cooper and Cooper defined the Oranda formation and separated it from the top of the Chambersburg formation. In 1949 Craig made an exhaustive study of the Middle Ordovician rocks above the Stones River group in south-central Pennsylvania. His studies led to a complete revision of the formation. Butts' Chambersburg was divided into two formations: The Shippensburg and Mercersburg formations. Each of these formations in turn was subdivided into three and two members respectively. Craig's divisions have not been carried into Virginia and West Virginia, but some of his formations are certainly there. In the vicinity of Strasburg, Va., it is possible to recognize part of the Shippensburg formation, and the upper massive beds just below the Oranda formation suggest some part of the Mercersburg formation. This subject is discussed further under the Edinburg formation.

In Virginia, Cooper and Cooper felt that the removal of the Lowville and Oranda from the Chambersburg formation so altered the stratigraphic value of

the name that it no longer was of use in that State. Cooper and Cooper therefore proposed the name "Edinburg formation" which is the Chambersburg formation minus Oranda and Lowville but including some uncertain layers at the bottom: Botetourt and *Cybeloides* bed.

Butts believed that the Chambersburg in Virginia was superposed on the Athens limestone which he had identified in northern Virginia. Cooper and Cooper, however, contend that the Chambersburg and Virginia Athens (now Liberty Hall) are facies of each other. This subject is pursued at greater length under the Edinburg formation.

The brachiopods of the Chambersburg formation are listed under the new and more restricted units of Craig, and Cooper and Cooper.

Chatham Hill formation (B. N. Cooper and G. A. Cooper).—This formation is named from exposures adjacent to Virginia Highway 16 along the lower northwestern slopes of Walker Mountain. The base of the formation is generally not well exposed and is transitional with the underlying black graptolitic shales (Rich Valley formation), but the top is prominently defined by the succeeding ledges of calcarenite forming the lower part of the Wassum formation. The total thickness is about 450 feet in the type section 2 miles south of Chatham Hill, Chatham Hill (T.V.A. 218-NE) Quadrangle. The upper 150 feet is cherty, dark bluish-gray limestone containing *Echinosphaerites*, *Calliops strasburgensis*, and *Nidulites pyriformis*, as well as numerous brachiopods. The lower beds are not so fossiliferous but contain *Lonchodomas*, *Robergia*, and *Bronteopsis*. Generally just above the thin zone with *Nidulites* a few beds are crowded with gastropods like those in the Peery limestone. The Chatham Hill formation thus includes part of the Ward Cove, the Peery, and the Benbolt formations of Tazewell County, Va.

Anisopleurella inaequistriata Cooper
Bimuria parvula Cooper
Camerella immatura Cooper
C. minuta Cooper
Conotreta multisinuata Cooper
Cristiferina cristata Cooper
Cyclospira sulcata Cooper
Ectenoglossa nymphoidea Cooper
Glyptoglossa sp. 1
Glyptomena sculpturata Cooper
Glyptorthis bellatula Cooper
Leptellina bella Cooper

L. sublamellosa Cooper
Mimella bursa (Raymond)
Opikina nasuta Cooper
Orthambonites bellus Cooper
O. parvicrassicostratus Cooper
Oxoplectra multicostellata Cooper
Plectocamara rotunda Cooper
Scaphorthis virginienensis Cooper
Skenidioides mediocostatus Cooper
Sowerbyella nasuta Cooper
S. perplexa Cooper
Trematis ? *parva* Cooper

Correlation of Chatham Hill formation.—The brachiopods listed from this formation are obviously related to those of the Arline, Effna, Botetourt, and Pratt Ferry formations, but in addition some Benbolt types appear. Similarity to the Edinburg formation is also evident.

Chickamauga limestone.—Except for Butts' use of the name Chickamauga in Alabama, this designation has long since passed into disuse. The name was so broadly used throughout the Southern Appalachians that it lost its value when the Middle and Upper Ordovician limestones and shales were studied in

detail. As originally defined by Hayes for exposures in the valley of West Chickamauga Creek, the Chickamauga limestone embraced all the strata between the Knox and the Rockwood formations. This included what is now known as the Murfreesboro, Lenoir, Mosheim, Lebanon, Lowville, Trenton, and Upper Ordovician.

It is of interest to point out the composition of the type Chickamauga because of the interpretation put on it by Dr. Butts. Northwestern Georgia is one of the areas of the Chickamauga limestone in which Dr. Butts discovered that the "Mosheim" limestone overlies the Murfreesboro limestone and that the Lenoir of the Appalachians is equivalent to the Ridley limestone of the Central Basin. This correlation, however, has caused a great deal of mischief.

The location in which these views were established is in the long sequence exposed at intervals along the road from Pond Spring to Catlet Gap, Kensington (T.V.A. 106-SE) Quadrangle, Ga. On the south bank of West Chickamauga Creek and on the east side of the bridge about $\frac{3}{4}$ mile south of Pond Spring, limestones occur which contain numerous large *Leperditia* interbedded with calcilitites that weather to a white-crusts surface. These limestones have the lithology and some of the fossils of the Murfreesboro and were so correlated by Butts. The ostracod beds are succeeded by calcilitite, massive and strongly resembling the Mosheim. This bed was identified as Mosheim by Dr. Butts who thus established the position of the Mosheim above the Murfreesboro. The "Mosheim" bed is overlain in this section by dark limestones containing black chert and specimens of the gastropod identified as *Maclurites magnus* by Dr. Butts. Because of the black chert and the gastropod this limestone was linked to the dark chert- and *Maclurites*-bearing limestones of the Southern Appalachians regardless of other considerations and disregarding the fact that the chert contained *Tetradium* like *T. cellulsum*. Because of its occurrence above the Murfreesboro, this dark limestone was correlated with the Ridley limestone of the Central Basin which also contains *Maclurites*. This was done in spite of the fact that the chert and other fossils in true Ridley are quite different from those in the type Chickamauga limestone.

Just north of the intersection of the Catlet Gap road and the road to Davis Crossroads, and lying on the *Maclurites* beds, are calcareous shaly limestones containing *Fascifera* in abundance. These were correlated with Lebanon by Dr. Butts. The presence of the latter genus is a link to the true Ridley of the Central Basin area rather than to Lebanon. The *Fascifera* beds are followed by thin-bedded limestones which are probably of Ridley age because they contain *Mimella* and *Chaulistomella*. They are well exposed in a quarry on the west side of the Catlet Gap road about half a mile south of the intersection mentioned above where many Wardell-Ridley types occur: *Ancistrorhyncha*, *Öpikina speciosa*, *Doleroides*, *Hesperorthis australis*, and *Protozyga rotunda*. Typical Lebanon thin-bedded limestone with yellow shaly partings and containing *Hesperorthis* and *Sowerbyella* in abundance occurs beside the road 0.7 mile south of the Catlet Gap-Davis Crossroads road intersection and for 0.3 mile farther south.

Above the Lebanon, exposures are poor and infrequent. Limestone with *Tetradium* in abundance occurs 1.35 miles south of the intersection beside a small stream in a pasture on the west side of the road. This limestone is suggestive of some seen in the Moccasin or Carters. Undoubted Trenton with *Hebertella frankfortensis* was seen in a bluff on the south side of the same brook where the *Tetradium* beds were seen.

The section just described is herein somewhat differently interpreted. The lowest beds containing *Leperditia* are truly Murfreesboro limestone, but to this formation would be assigned the so-called Mosheim and the overlying *Maclurites*-bearing beds as well. The type Murfreesboro limestone of the Central Basin contains much black chert and also has rare *Maclurites*. Therefore, all these cherty beds, the Mosheim, and the Murfreesboro are correlated with the Murfreesboro limestone of the Central Basin area.

The shaly beds containing *Fascifera* are thought to be Ridley (Pierce) because this is the only horizon for this genus in the Central Basin. The higher beds containing *Mimella* and rare *Doleroides* suggesting Lebanon probably also belong to the Ridley. These beds, like those below, have the lithology of the Pierce and suggest that the characteristic massive Ridley limestone of the Central Basin is represented eastward by shalier beds. In addition to *Mimella*, which occurs only in the Pierce in the Central Basin, *Ancistrorhyncha*, a common Ridley fossil, is frequent in the lower layers of the quarry mentioned above. The *Sowerbyella* beds are quite characteristic of the Lebanon. This brachiopod is characteristic of the Lebanon in the Central Basin and is extremely rare in any of the Stones River beds outside the Lebanon. The *Tetradium* beds are thought to be Carters.

In Alabama, in the belts west of the Cahaba Coal Field area, the name "Chickamauga limestone" has been used in the maps of the U. S. Geological Survey (Birmingham, Bessemer). As in Georgia, the name really is not that of a formation, but is a group term embracing several distinguishable formations. According to Butts (1927, p. 7) fossils taken from the Chickamauga limestones of Alabama were identified by Ulrich, who recognized in them representatives of the Stones River group, Black River (Lowville) limestone, and Trenton limestone. In these identifications Butts and Ulrich appear to be mistaken. It is believed by the present writer that the so-called Stones River and Black River limestones actually represent part of the true Stones River and the Carters limestones of the Central Basin sequence. The overlying Trenton limestones can also be related to Trenton strata of the same region. In the quarry at Gate City, Leeds (15') Quadrangle, fossiliferous limestones containing representatives of the Lebanon and Carters formation are overlain by Trenton (Curdsville).

In the Birmingham and Bessemer quadrangles, the Chickamauga limestone is marked by a basal conglomerate, the Attalla conglomerate, 20 to 40 feet thick and containing angular to subrounded pebbles of chert. The rock varies from a coarse sand to a coarse conglomerate. In places, as at Foster Mountain, the lower part of the "formation" (about 25 feet) is composed of shale often mottled or streaked with purple and containing a medium-sized *Lingulella* (*L. fostermontensis* (Butts)) and suggesting the Blackford formation.

The name "Chickamauga" is no longer a useful formation name because the limestone can be broken into recognizable formations to which the names from the Central Basin may be applicable. The Chickamauga is probably not synonymous with the Pelham limestone proposed by E. A. Smith a year earlier.

Chota formation (R. B. Neuman, 1956).—This name was introduced for the "Sandstone lentil in the Sevier," described by Keith, in the belt along the Great Smoky Mountains in East Tennessee. The formation consists of gray sandstone for the most part, calcareous in places, 550 to 900 feet thick. The Chota occurs just under a sandstone containing *Dinorthis transversa* Willard. On the basis of this occurrence the formation is placed opposite the Benbolt formation of western belts.

Clifffield formation.—This name was proposed by Cooper and Prouty (1943, p. 862) for a succession of limestone beds which made a convenient unit for mapping purposes. The formation northwest of Clinch Mountain was divided into five members: Blackford, Five Oaks, Lincolnshire, Ward Cove, and Peery. Subsequent studies have shown that each of these members is best recognized as a formation; consequently, the brachiopods from each are listed under the respective names.

Clifffield group.—Under this heading B. N. Cooper (1944, p. 54-69) groups rock units equivalent to the aggregate of members under the Clifffield formation. These are Blackford, Five Oaks, Lincolnshire, Effna, Whitesburg, Athens, and Peery. It will be seen from this listing that the position of the Ward Cove is occupied by three units, Effna, Whitesburg, and Athens, of unlike character. The brachiopods of these units are discussed under the Effna and Rich Valley formations.

Clover member of Loysburg formation.—This is the top member of the Loysburg formation in central Pennsylvania. The name was proposed by Kay (1944, pp. 4-6) for sublithographic limestone, 40 to 80 feet thick, interfingering with the magnesian rock of the Loysburg formation and underlying the Hatter formation. The member to date has produced no brachiopods.

Collierstown formation.—This unit was named by Cooper and Cooper (1946, p. 60) for Collierstown on Collier Creek, west of Lexington, Va. The type section is just north of Virginia State Highway 241, 2 miles east of Collierstown. This limestone consists of a maximum of 75 feet of shell limestone and calcarenite with minor parts of buff shale and argillaceous limestone. It is known only in the westernmost belt of Middle Ordovician limestone along the base of Little North Mountain. The limestone is crowded with a few species of poorly preserved brachiopods, among them *Rafinesquina*.

Cyclospira sp.
Doleroides sp.

Rafinesquina trentonensis (Conrad)
Zygospira sp.

Correlation of Collierstown formation.—The Collierstown formation occupies the same stratigraphic position in the southern part of the Shenandoah Valley as the Oranda formation in northern Virginia. It also has a similar position to the Cane Creek formation.

Columbiana formation (B. N. Cooper and G. A. Cooper).—In southeastern belts of the Appalachian Valley in Alabama, the Pratt Ferry limestone is succeeded by a body of black graptolitic shale varying in thickness from a few inches up to 325 feet. The variation in thickness of the shale reflects the major disconformity between it and the overlying Devonian Frog Mountain sandstone. The Columbiana shale is approximately the same as the Rich Valley shale of Virginia and the Paperville shale of the Bristol district of Virginia and Tennessee. The profusion of graptolites in the Columbiana shale has been described by Decker (1952, pp. 14-26) from exposures near Pratt Ferry, Blocton (15') Quadrangle, Ala. The type section of the Columbiana formation is just west of Simpson Spring, 2½ miles northwest of Calera. The name is from the Columbiana (15') Quadrangle in which the east side of Calera is located.

Brachiopods are rare in the black shales, and only one is listed from the Columbiana formation:

Lingulella tenuitesta Cooper.

Curtin formation.—This formation (Kay, 1944, p. 19) is exposed in parts of Centre, Clinton, and Lycoming Counties, Pa., and ranges in thickness from 0 to 150 feet. The formation is composed of two members: Valley View and Valentine. (See further discussion under these headings.)

Dot formation.—This name was proposed by Miller and Brosge (1950) for dolomitic limestone, reddish and green mudstone, dove-gray limestone, and light-gray dolomites with a prominent conglomeratic zone of chert and dolomite pebbles at the base. The name is from exposures along Virginia State Highway 70 just west of Dot, but the type section is from the blind spur at the south end of the railroad cut at Hagan, Rose Hill (T.V.A. 161-NE) Quadrangle. No fossils were seen or have been reported.

Correlation of Dot formation.—Only lithology and position can be used to correlate this formation. Lithology indicates a correlation with the Blackford facies at the base of the Middle Ordovician sequence in western Virginia, but its position indicates that the Dot formation is probably a correlative of the Lincolnshire-Elway formations.

Douglas Lake member of Lenoir formation.—This name was proposed by Josiah Bridge for exposures at Douglas Lake Dam. The rocks are an argillaceous dolomite attaining a maximum thickness of 30 feet and usually conglomeratic at the base. The type section is 1½ miles upstream from Douglas Dam, near Shady Grove on the Kykers Ferry (T.V.A. 156-NE) Quadrangle. The Douglas Lake dolomites underlie Lenoir limestone with *Rostricellula*. The member is patchy in occurrence. The facies is like that of the Blackford which displaces the Lenoir to the west.

Doylesburg member of Shippensburg formation.—This member overlies the Fannettsburg member of the Shippensburg formation and is unconformably overlain by the Nealmont formation. The member was named by Craig (1949, p. 727) with its type section 1 mile S. 70° W. of St. Thomas, Pa. The formation consists of dove, massive, white-weathering limestone in the eastern belts,

but interfingers with fine- to medium-grained, platy limestone with beds of dove limestone conglomerate. The member ranges in thickness from 40 feet southwest of Doylestown, Pa., to 6 feet at Rockdale, northwest of Williamson, Pa. The member is absent in the eastern belts. The Doylestown member is especially characterized by *Cryptophragmus* and *Tetradium cellulosum*. Brachiopods are few:

**Mimella* sp.

Zygospira recurvirostris (Hall)

Correlation of Doylestown member.—*Cryptophragmus* and *Zygospira* are a combination suggesting correlation with the Witten formation and the Lantz Mills facies of the Edinburg formation.

Dryden formation (B. N. Cooper and G. A. Cooper).—This name is used for the combined Benbolt and Wardell formations where they are not separated by the Gratton formation. The type section is in the fields on both sides of the highway about 1 mile east of Dryden and less than 1,000 feet west of Stallard Ford bridge across Powell River, Keokee (T.V.A. 178-SW) Quadrangle, Lee County, Va. This formation consists mostly of limestone but may contain conspicuous amounts of shale, as at Rye Cove and Lone Mountain. It attains a thickness of 300 to 500 feet. The formation occurs in the western belts of Virginia and East Tennessee. It is usually fairly easy to identify the Benbolt or Wardell portions of the sequence in the lower and upper parts, respectively, but to find the boundary line between the two is more difficult. Usually the zone of *Dinorthis transversa* denotes Benbolt, and the zone of *Hesperorthis australis* indicates the Wardell part. In some instances in the descriptive part of this monograph it is stated that the fossils come from Benbolt (or Wardell) although they are actually in the Dryden formation. The parts are so clear in these instances that it is thought better to keep the added refinement. In other instances the species are said to be from the Benbolt (or Wardell) part of the Dryden formation.

In the vicinity of Lone Mountain, near Tazewell, Tenn., some mingling of Benbolt and Wardell types can be detected. Here *Doleroides* appears low in the section in such a position that it might be interpreted as belonging to the Benbolt part of the Dryden formation. The listed fossils show the Benbolt-Wardell relationships.

Chaulistomella brevis (Willard)

Dinorthis transversoides Cooper

Doleroides irregularis Cooper

D. regularis Cooper

Fascifera stonensis (Safford)

F. subcarinata Ulrich and Cooper

Glyptambonites platys (Butts)

Hesperorthis australis Cooper

Mimella globosa (Willard)

Murinella muralis Cooper

Oligorhynchia sp. 1

Opikina speciosa Cooper

O. varia Cooper

Petrocrania sp. 1

Protozyga rotunda Cooper

Rostricellula ovata Cooper

R. rostrata Ulrich and Cooper

R. tumidula Cooper

Sowerbyella compacta Cooper

Strophomena grandimusculosa Cooper

S. inspeciosa Willard

S. medialis Butts

Edinburg formation.—This name was proposed by Cooper and Cooper (1946, p. 78) for the Chambersburg limestone of Virginia minus the Oranda. The type section was taken near the Shenandoah River, 1.5 miles N. 61° E. of Edinburg, Shenandoah County, Va. The lithology of the formation is so variable that two facies and one member have been defined to make it better understood. The Liberty Hall facies of the Edinburg formation consists of black, slabby conchoidally-fracturing limestone that weathers to an ash gray. This facies was called Athens by Butts (1940b, p. 159) and was thought by him to pinch out under the "Chambersburg" (Butts, 1940b, p. 196) in the vicinity of Edinburg. Cooper and Cooper, on the other hand, contend that the Virginia "Athens" is a black limestone facies, including some black shale with graptolites, which inter-fingers with the Lantz Mills facies of the Edinburg. This member consists of cobbly limestone that comes to occupy more and more of the sequence in the northern part of the range of the formation.

At the base of the formation is a granular, often brown-weathering and impure limestone containing fossils that constitute a very distinctive assemblage. This is the Botetourt formation, which is definitely related to part of the Arline, Effna, and Pratt Ferry formations. It is thus now excluded from the Edinburg formation and combined with the *Cybeloides* bed under it.

Under the probable Boteourt formation at Edinburg dam and along Tumbling Run 1½ miles southwest of Strasburg, Va., where a superb section is exposed, dark slabby limestones appear between the Lincolnshire and the Botetourt. These limestones were placed by Butts (1949b, p. 197) in the Chambersburg, but were left in the Lincolnshire by Cooper and Cooper. Faunally they are most like the overlying Botetourt and are better placed with it. They are called the *Cybeloides* beds after a trilobite which is fairly common in this limestone.

Cooper and Cooper (1946, pp. 81, 94, 95) note a number of sections in which the sequence is well divided between the two facies. In the northern range of the formation where the Lantz Mills facies is dominant it is possible to distinguish some elements described by Craig in Maryland and southern Pennsylvania. Craig's Shippensburg formation is mainly composed of Lantz Mills facies rocks. The upper massive beds with *Camarocladia* in the Strasburg section undoubtedly belong to Craig's Mercersburg formation.

Fossils are numerous in the Edinburg formation, and three major zones can be readily recognized: The first is the *Cyrtonotella* zone, which also abounds in *Echinosphaerites* as well as the zone-naming brachiopod; the next zone is characterized by the peculiar *Nidulites pyriformis*; and the third zone is that of the massive limestones with *Camarocladia*. Brachiopods occur in all the zones; those of the *Cyrtonotella* zone indicate the faunas of the combined interval of Effna, Ward Cove through Benbolt, in terms of the Tazewell County sequence. Fossils taken from the *Nidulites* zone are most suggestive of an early Trenton (Rockland) level although many genera from the lower beds pass upward through the Edinburg, Oranda, and into the overlying Martinsburg (=Salona). No good brachiopods have been taken from the *Camarocladia* beds.

Edinburg formation (*Echinospaerites-Cyrtonotella* zone)

| | |
|---|---|
| <i>Bilobia virginiensis</i> Cooper | <i>Öpikina bellula</i> Cooper |
| <i>Bimuria parvula</i> Cooper | <i>Ö. dorsatiformis</i> Cooper |
| <i>Christiania platys</i> Cooper | <i>Öpikina</i> sp. 3 |
| <i>C. subquadrata</i> (Hall) | <i>Orthambonites bielsteini</i> Cooper |
| <i>Cristiferina cristata</i> Cooper | <i>Oxoplectia multicostellata</i> Cooper |
| <i>Cyphomena angulata</i> Cooper | <i>Palaeoglossa</i> sp. 1 |
| <i>Cyrtonotella subplana</i> Cooper | <i>Paucicrura matulina</i> Cooper |
| <i>Dactylogonia strasburgensis</i> Cooper | <i>Perimecocoelia semicostata</i> Cooper |
| <i>Dinorthis transversa</i> Willard | <i>Plectocamara magna</i> Cooper |
| <i>Eoplectodonta ? dubia</i> Cooper | <i>Ptychoglyptus virginiensis</i> Willard |
| <i>Laticrura pionodema</i> Cooper | <i>Scaphorthis kayi</i> Cooper |
| <i>Leptaena ordovicica</i> Cooper | <i>Sowerbyella aequicostellata</i> Cooper |
| <i>Leptellina</i> sp. 1 | <i>Trematis</i> sp. 3 |
| <i>Limbimurina brevilimbata</i> Cooper | |

Edinburg formation (*Nidulites* zone)

| | |
|-------------------------------------|---|
| <i>Christiania platys</i> Cooper | <i>Ö. dorsatiformis</i> Cooper |
| <i>C. subquadrata</i> (Hall) | <i>Paucicrura virginica</i> Cooper |
| <i>Cyphomena angulata</i> Cooper | <i>Paurorthis spinosa</i> Cooper |
| <i>Dinorthis transversa</i> Willard | <i>Plectocamara transversa</i> Cooper |
| <i>Hesperorthis</i> sp. 2 | <i>Skenidioides obtusus</i> Cooper |
| <i>Lingulasma</i> sp. 3 | <i>Sowerbyella aequicostellata</i> Cooper |
| <i>Öpikina alata</i> Cooper | |

Effna formation.—This name was proposed by B. N. Cooper (1944, p. 59) for calcarenites overlying the Lincolnshire limestone and underlying the "Whitesburg" limestone. The type section is in and near the McNutt Quarry located about 12 miles southwest of Bland (1½ miles southeast of Sharon Springs), Va. The formation is generally composed of calcarenite or shell debris or both. At the type locality it attains a thickness of about 221 feet, but it is thinner to the southwest along the same belt and also in the northern belt. One of the best places for the study of this formation is at the Porterfield Quarry, 5 miles east of Saltville. At this place the Effna formed a great reef (now quarried away) at the base of the Rich Valley formation. The McNutt Quarry locality is also a reef, and it is likely that others appear along that line of outcrop. In Catawba Valley Effna banks of calcarenite appear at the same level and in places interfinger with the Botetourt formation as well as overlies it.

The fauna of the Effna is essentially that of the Arline formation of Tennessee. At the Porterfield Quarry the Effna rests on a thin tongue of the Arline formation. It is evident, then, that the Effna is of the same age as part of the Arline formation. It is therefore also evident that the Effna formation is older than the Red Knobs formation which contains a thick calcarenite that overlies the Arline in the Friendsville area.

Brachiopods are abundant in the reefy limestone as follows:

| | |
|--|---|
| <i>Bimuria superba</i> Ulrich and Cooper | <i>C. plana</i> Cooper |
| <i>Camerella minuta</i> Cooper | <i>C. triangulata</i> Cooper |
| <i>Christiania subquadrata</i> (Hall) | <i>Cyrtonotella grandistriata</i> (Willard) |
| <i>Conotreta cuspidata</i> Cooper | <i>Dactylogonia</i> sp. 5 |

Doleroides ? ponderosus Cooper
Eridorthis inexpectata Cooper
Glyptambonites glyptus Cooper
Glyptoglossa sp. 1
Glyptomena parvula Cooper
Glyptorthis glypta Cooper
Laticrura pionodema Cooper
Leptellina pulchra Cooper
L. tennesseensis Ulrich and Cooper
Lingulella lirata Cooper
L. subparallela Cooper
Lingulella sp. 4
Obolus ? virginiensis (Willard)
Obolus sp. 5
Oxoplectia abnormis Cooper
O. depressa Cooper
O. gibbosa Cooper
O. holstonensis Willard
Pachyglossa pachydermata Cooper
Perimecocoelia semicostata Cooper

P. triangulata Cooper
Petrocrania ? magna Cooper
Phragmorthis buttsi Cooper
Pionomena ? dubia Cooper
Productorthis agilera (Raymond)
Protozyga tumida Cooper
Pseudobolus sp. 1
Ptychoglyptus virginienensis Willard
Ptychopleurella medicostata Cooper
P. rectangulata Cooper
Scaphorthis perplexa Cooper
Schizambon cuneatum Willard
Schizotreta pannea (Willard)
S. shuleri (Willard)
Skenidioides transversus Cooper
Sowerbyella negritus (Willard)
Spondylotreta ? declivis (Willard)
Taphrorthis peculiaris Cooper
Titanambonites crassus Cooper

Correlation of Effna formation.—A glance over the faunal list will show that the Effna formation is related to the Arline formation of Tennessee and southern Virginia, the Little Oak formation of Alabama, the Botetourt formation (or member) of central and northern Virginia, and the *Cyrtototella* zone of the Edinburg formation. A few species such as *Bimuria superba* occur in the Arline and the Effna. *Ptychoglyptus* appears to be confined to this suite of formations. In Catawba Valley not only the fauna relates the Effna to the Botetourt but the fact that the two interfinger indicates a close relationship between them. In the Porterfield Quarry the Effna limestone is underlain by a thin, dark, siliceous limestone that appears to be a tongue of the Arline formation.

Eggleston formation.—This name is applied to the dark-gray calcareous mudrocks overlying the Moccasin formation and underlying the Martinsburg formation (Curdsville). Parts of the limestone, particularly those associated with metabentonites, are characterized by cuneiform jointing. Two thick metabentonites appear in the upper part of the section and can be seen in many places. This formation appears in the western belts of southwestern Virginia and East Tennessee on the northwest slope of Wallen Ridge from Tennessee nearly to Big Stone Gap, and throughout Russell and Giles Counties, Va.

The following brachiopods have been reported:

Dalmanella rogata (Sardeson) = *Paucicrura rogata* (Sardeson)

Pholidops sp. = *Cramiops* sp.

Rafinesquina alternata (Conrad) = *Rafinesquina trentonensis* (Conrad)

**R. minnesotensis* (N. H. Winchell) = *Opikina minnesotensis* (N. H. Winchell)

**Strophomena incurvata* (Shepard)

Zygospira recurvirostris (Hall)

Eidson member of Lincolnshire formation.—This name (B. N. Cooper and G. A. Cooper) is used for the thinned portion of the Lincolnshire formation underlying the Hogskin shale in the belts where that is present: Clinch Valley,

Hogskin Valley, and Beaver Valley. The rock is dark limestone containing black chert. The type section is just north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle. Brachiopods are:

Dinorthis atavoides Willard
Macrocoelia duplistriata Willard
Sowerbyites triseptatus (Willard)

Ellett formation (B. N. Cooper and G. A. Cooper).—This name is proposed for dark-gray limestones between the top of the Knox (Lower Ordovician) and the Botetourt in the belt east of Roanoke Valley. The formation contains equivalents of the Lenoir, Whistle Creek, and probably Lincolnshire. Silicified fossils are abundant at Ellett and in Catawba Valley. The type section is in the fields west of County Road 615, about 800 feet north of the Virginian Ry., near Ellett Station, Blacksburg (15') Quadrangle, Montgomery County, Va.

Camerella sp.
Hesperorthis longirostris Cooper
Mimella gilberti Cooper
Multicostella quadrata Cooper

Öpikina sp. 5
Rostricellula multicostata Cooper
Stenocamara perplexa Cooper
Valcourea austrina Cooper

Elway formation.—B. N. Cooper (1945b, p. 42) proposed this name for part of Butts' Blackford formation which yields a blocky chert when weathered. The rock is usually a fine-grained, light-gray limestone interbedded with layers of dark-gray to black chert. In places, near Gate City, Va., and in Clinch Valley, the limestone is often a gray calcarenite abounding in large ostracodes. The formation varies from 30 to slightly more than 70 feet in thickness. It is widespread in western belts of southwestern Virginia and Tennessee. The name is taken from Elway on U. S. Highway 19 near Lebanon, Russell County, Va., and the type section is near Blackford, Russell County. A few species of brachiopods are common:

Camerella costellata Cooper
C. indefinita Cooper
C. multiplicata Cooper
C. perplexa Cooper
Dinorthis holdeni (Willard)
Lingulella decorticata Cooper

Mimella intermedia Cooper
Mimella sp. 1
Pionomena neumani Cooper
Protozyga microscopica Cooper
Rhipidomena subparallela Cooper

Correlation of Elway formation.—This formation, by the presence of *Rhipidomena*, belongs in the suite with Lincolnshire and Whistle Creek. The Elway may be a partial equivalent of the Whistle Creek because both formations contain *Dinorthis holdeni*.

Eyer member of Hatter formation.—Kay (1944, p. 7) proposed this name for a gray, granular limestone, ranging from 6 to 37 feet in thickness, which lies on the Clover member of the Loysburg formation and underlies the Grazier member of the Hatter formation. The Eyer is restricted to south-central Pennsylvania. The rock contains massive heads of *Tetradium fibratum* Safford. Kay (1944, p. 12) lists the following brachiopods:

Campylorthis sp. = *Chaulistomella* sp.
Glyptorthis sp.

Öpikina sp.

Pionodema ? sp.

Rhynchocamara sp. cf. *R. plicata* Schuchert and Cooper = *Camerella* cf. *C. plicata* Schuchert and Cooper

Strophomena sp.

Correlation of Eyer member.—The faunal list indicates correlation with the suite of rocks from Benbolt up. *Campylorthis*, and *Strophomena* together with a *Camerella* suggestive of *C. plicata* Schuchert and Cooper, indicate correlation at about the level of the Wardell.

Fannettsburg member of Shippensburg formation.—This member (Craig, 1949, p. 722), at its type section 1 mile S. 70° W. of St. Thomas, Pa., consists of 39 feet of light-gray crystalline limestone in heavy beds. The Fannettsburg overlies the Pinesburg member of the Shippensburg formation in eastern belts. It is conformably overlain by the Doyleburg formation. In western belts it is overlain unconformably by the Mercersburg formation. In eastern belts the member is fine-grained, dark gray, and slabby, but westward becomes more coarsely granular, the two types of lithology intertonguing. The member is thickest, 263 feet, in the railroad cut southwest of Marion, but it thins rapidly to the northeast and west to 7 feet in the former direction and 19 to 55 feet to the west. Craig (1949, p. 726) correlates the member with the upper part of the Hostler and the lower part of the Snyder. The Hostler member contains numerous *Solenopora*, a feature also characteristic of the Fannettsburg. *Cryptophragmus* occurs in the upper part of the Fannettsburg and forms the basis for the correlation with the Snyder.

Fossils are said to be common in the Fannettsburg, and the following brachiopods are recorded by Craig (1949, p. 724):

| | |
|--|---|
| <i>Campylorthis</i> sp. cf. <i>C. magna</i> Schuchert and Cooper = <i>Chaulistomella</i> sp. | * <i>Öpikina</i> sp. aff. <i>Ö. ampla</i> Wilson |
| * <i>Corineorthis</i> sp. | * <i>Öpikina</i> sp. aff. <i>Ö. gloucesterensis</i> Wilson |
| <i>Glyptorthis</i> sp. | * <i>Öpikina</i> sp. cf. <i>wagneri</i> (Okulitch) |
| * <i>Hebertella</i> sp. | * <i>Oxoplectra simulatrix</i> (Bassler) |
| <i>Hesperorthis tricenaria</i> (Conrad) | <i>Resserella</i> sp. |
| <i>Leptaena</i> ? sp. | cf. <i>Rostricellula plena</i> (Hall) |
| <i>Leptaena</i> sp. cf. <i>L. homostriata</i> Butts | <i>Sowerbyella</i> sp. aff. <i>S. alternata</i> Butts |
| <i>Leptobolus</i> sp. | <i>Sowerbyella</i> sp. cf. <i>aequistriata</i> (Willard) |
| <i>Mimella</i> sp. | " <i>Sowerbyella</i> " sp. cf. " <i>S.</i> " <i>pisum</i> (Ruedemann) |
| * <i>Multicostella</i> sp. | <i>Strophomena</i> sp. |
| | <i>Zygospira recurvirostris</i> (Hall) |

Correlation of Fannettsburg member.—Its position between Pinesburg and Doyleburg members of the Shippensburg formation indicates correlation with Wardell, but *Cryptophragmus* and *Zygospira* indicate that it may have affinities with the Witten formation.

Farragut formation.—This name was proposed by C. E. Prouty (1946, p. 1156) for the "Holston" of the Concord, Tenn., belt. Prouty believes the name "Holston" to have no validity as a formation because Keith proposed the term for marbles regardless of their stratigraphic position. The type section of the Farragut limestone is 1.4 miles east of Lowes Ferry, 9½ miles southwest of Knox-

ville. The rock is a calcarenite, generally gray in color but often pink or reddish. This formation has been correlated with the Effna and Lincolnshire formations. The latter correlation is certainly wrong because the Effna formation is the partial equivalent of the Arline formation containing *Christiania* which overlies the Lincolnshire as shown by the Edinburg-Lincolnshire relationship in northern Virginia. Prouty (1946, p. 1157) speaks of the Athens formation being younger than the Farragut. This, too, is an error because the type Athens is the time equivalent of the Arline. Fossils are fairly common in the Farragut but are difficult to identify. This is true of most of the calcarenite formations because the fossils must be broken out of the rock and specific details of the ornamentation are lost. The known brachiopods are:

Dactylogonia palustris (Willard)

Leptellina cf. *L. elegantula* (Butts)

Multicostella whitesburgensis Butts = *M. bursa* (Raymond)

Multicostella sp.

Oxoplectra holstonensis Willard

Schizambon sp.

Correlation of Farragut formation.—This formation appears to be equivalent to the Arline and thus a correlate of the Effna.

Fetzer tongue of Arline formation (B. N. Cooper and G. A. Cooper).—This thin but persistent bed is recognized in southeastern belts of the Southern Appalachian region from Wytheville, Va., to Georgia. In the type section along U. S. Route 64 about 3 miles southwest of Benton Station, Benton (T.V.A. 126-NW) Quadrangle, Polk County, Tenn. the tongue consists of 6 to 8 feet of nodular, crumbly limestone with thin granular interbeds. The division is readily identified by its characteristic assemblage of fossils which includes *Trinodus elspethi*, *Bronteopsis gregaria*, *Nicholsonella*, *Christiania*, *Bimuria*, *Titanambonites*, *Cyrtotonella*, and other brachiopods of the Arline. The division is generally more argillaceous than the underlying beds of the Lenoir limestone. The Fetzer is virtually the same unit as the Botetourt limestone member of the Edinburg formation of the Shenandoah Valley of Virginia. The Fetzer is not as silty and hard as the Botetourt but rather partakes of the general lithology of the Arline limestone, and is a thin tongue of that formation. The name is taken from Fetzer Creek, not far from the type section of the Fetzer along Ocoee River. Additional brachiopods are:

Leptellina tennesseensis Ulrich and Cooper

Palaeostrophomena superba Cooper

Titanambonites amplius (Raymond)

Five Oaks formation.—This name was applied in southwestern Virginia by Cooper and Prouty (1943, p. 863) to a dove-gray calcilutite overlying the Blackford (Elway) formation and underlying the Lincolnshire formation. No brachiopods have been taken from it. This is one of the several calcilutites mistaken for the Mosheim of Tennessee. The Five Oaks actually is higher in the section than the true Mosheim, which is a part of the Lenoir formation. The latter is a partial equivalent of the Blackford formation below the Five Oaks.

Fleanor formation.—This name is proposed by B. N. Cooper and G. A. Cooper for about 200 feet of maroon and red shale, thin gray limestones, siltstone, and calcarenite. The name is taken from the exposures on a farm lane along Foster Branch near Fleanor Mill, 2 miles northeast of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle, Tenn. The formation contains:

Rhipidomena mesleri Cooper

Oligorhynchia subplana Cooper

Mimella costellata Cooper

Plectocamara sp.

Correlation of Fleanor formation.—The few fossils found in this formation clearly indicate correlation with the Hogskin member of the Lincolnshire formation.

Gratton formation.—This name was applied by Cooper and Prouty (1943, p. 872) to a thick limestone occurring in Virginia between the Benbolt and Wardell formations in the belts northwest of Clinch Mountain. In general, the formation consists of a lower zone of straticulate calcilutite with mud-cracked surfaces and edgewise conglomerate ranging from 15 to 30 feet in thickness. The upper part of the formation averages about 60 feet of medium- to thick-bedded dove-gray calcilutite. Gratton fossils are difficult to identify, but *Tetradium* is abundant and *Cryptophragmus* is present. No brachiopods have been reported from the formation. The Gratton is a partial equivalent of the Wardell.

Grazier member of Hatter formation.—This is dark, dense, heavy-bedded limestone with wavy partings, reaching 35 feet in thickness. The member was named by Kay (1944, p. 10), and its type section is at Union Furnace, Pa. In south-central Pennsylvania the member rests on the Eyer limestone, but to the northeast it overlies the Clover member of Loysburg formation. The thickness of the member decreases to the southeast, and it is only 7 feet thick in northern Path Valley. At Waterside, Pa., the base of the member is characterized by a coquina layer composed of *Pionodema*. The following brachiopods were seen:

Glyptorthis sp.

Pionodema sp.

Mimella sp.

Pionomena neumani Cooper

Opikina sp.

Strophomena sp.

Correlation of Grazier member.—The presence of *Pionodema* indicates a correlation in the post-Benbolt suite.

Greencastle bed (Bassler, 1919, p. 143).—Craig (1949, p. 739) suggests the abandonment of this name because the Greencastle in several sections is a confusion of parts of the Kauffman member of the Mercersburg formation. Furthermore, the section at Greencastle is poorly exposed and structural complications may have caused the repetition of *Echinosphaerites* and *Nidulites*. The formation probably belongs to the present Oranda formation.

Hardy Creek formation.—This name was proposed by Miller and Brosge (1950) for even-bedded, tan, dense, fine-grained limestone with oval chert nodules in a few beds. The thickness varies from 93 to 150 feet. The formation is poorly fossiliferous. This formation underlies the Cane Creek limestone and

overlies the Ben Hur formation. The name is taken from Hardy Creek in the Jonesville District, Va. Brachiopods present are:

Campylorthis sp.

Öpikina sp.

Pionodema minuscula Willard

Strophomena sp.

Zygospira recurvirostris (Hall)

Hatter formation.—This name was proposed by Kay (1944, p. 6) for a succession of limestones overlying the Loysburg formation and underlying the Benner formation in central Pennsylvania. It varies in thickness from 60 to 500 feet. It consists of three members: Eyer, Grazier, and Hostler. The brachiopod content is listed under the various members.

Heiskell shale.—Apparently the only appearance of this name in the literature is on a chart by E. O. Ulrich (1911, pl. 27) correlating the Ordovician formations of the eastern half of the United States. On Ulrich's chart, Heiskell is in the Tennessee Basin of the Appalachian Valley and in a division of this called the Pearisburg Trough. Heiskell shale is correlated with the Pearisburg limestone proposed by Bassler in 1907. According to Wilmarth, the shale was "Probably named for Heiskell, Knox Co., Tenn., in SE corner of Briceville quad." The Heiskell is indicated by Ulrich as overlying the Holston and underlying the Lowville.

At Heiskell a long sequence is fairly well exposed. Just east of the school grounds on the east side of the village *Cryptophragmus* occurs in abundance on the west side of a small stream. This would have been interpreted by Ulrich as Lowville limestone. Shaly beds are exposed at the four corners in the center of the village. These shales contain fossils of the Benbolt formation. Beneath them are limestones assigned to the Ward Cove formation, and beneath that limestones and red beds equivalent to the Hogskin and here called Fleanor formation. Thus the only rocks answering lithologically to the Heiskell are the Benbolt shales. Inasmuch as the name Heiskell was never established by definition or designation of a type section it cannot replace the well-established and validly proposed name of Benbolt.

Hermitage formation.—Butts identifies this formation in the Appalachians at Birmingham, Ala. The new species *Sowerbyella angulata* Cooper occurs in it.

Hogskin member of Lincolnshire formation.—This name is proposed here by B. N. Cooper and G. A. Cooper for yellow-weathering shale and cobbly limestone, both of "Ottosee type" and usually confused with that formation, lying between the Eidson member of the Lincolnshire formation and the Ward Cove or Rockdell formations. The Hogskin has not been identified outside of eastern Tennessee. Belts from the north side of Knoxville nearly to the Cumberland Front have this formation more or less well developed. One of the best displays is along the road from Thorn Hill to Washburn, especially at Red Hill about 4 miles west-southwest of Thorn Hill. It is also well displayed in the next belt to the north, in the Evans Ferry section along U. S. Highway 25E, north of Indian Creek in the southern part of the Howard Quarter Quadrangle. In the Heiskell-Maynardville belt the formation has passed over mostly to red

beds, but thin tongues of limestone contain the characteristic fossils of the formation. These red beds are well displayed near Heiskell and at Rose Hill near Maynardville. They also appear in the belt running through Clinton, Tenn.

The Hogskin member seems to be a time equivalent of the Lincolnshire which it displaces to the south and west. The faunal content generically is like that of the Lincolnshire, but some of the species are different.

In belts south of Knoxville some parts of the Sevier, as at Miser and south of Athens, contain fossils similar to those of the Hogskin. The species, however, appear to be different, and that part of the Sevier is related to the Benbolt rather than the Hogskin because the Sevier beds referred to overlies the Arline *Christiania* beds. The latter are related to the Ward Cove which in turn overlies the Hogskin. It is evident, therefore, that these Sevier beds have nothing to do with the Hogskin but merely simulate its facies and repeat its generic types.

Brachiopods are numerous in the Hogskin formation, as follows:

| | |
|--|--|
| <i>Atelelasma obscurum</i> Cooper | <i>Murinella biconvexa</i> Cooper |
| <i>A. platys</i> Cooper | <i>M. semireducta</i> Cooper |
| <i>Camerella bicostata</i> Cooper | <i>M. speciosa</i> Cooper |
| <i>C. quadriplicata</i> (Willard) | <i>Oligorhynchia angulata</i> Cooper |
| <i>Cyrtototella bella</i> (Schuchert and Cooper) | <i>O. subplana</i> Cooper |
| <i>Dactylogonia concentrica</i> Cooper | <i>O. subplana gibbosa</i> Cooper |
| <i>D. magna</i> Cooper | <i>Oxoplectia recta</i> Cooper |
| <i>D. parva</i> Cooper | <i>Paurorthis magna</i> Cooper |
| <i>Dinorthis willardi</i> Cooper | <i>Petrocrania cicatricula</i> Willard |
| <i>Dorytreta reversa</i> Cooper | <i>Plectocamara costata</i> Cooper |
| <i>Glyptorthis</i> sp. 2 | <i>Protozyga microscopia</i> Cooper |
| <i>Macrocoelia duplistriata</i> (Willard) | <i>Rhipidomena mesleri</i> Cooper |
| <i>Mimella costellata</i> Cooper | <i>R. tenuitesta</i> (Willard) |
| <i>M. similis</i> Cooper | <i>Schizotreta</i> sp. 1 |
| <i>M. tumida</i> Cooper | <i>Sowerbyites triseptatus</i> (Willard) |
| <i>Multicostella semisulcata</i> Cooper | |

Holston limestone.—This is another of the Appalachian names that has lost its usefulness by application to a lithology that occurs in many formations of different ages. The name was originally proposed not as a formation name but as applied to marble beds in the Chickamauga limestone. The name was later used as a stratigraphic term for marbles in Tennessee and Virginia that were thought to occupy a particular horizon, i.e., just above the "Lenoir." Recent work in Tennessee is reviving the term to be applied to the marbles in each of the belts in the vicinity of Knoxville. It has not yet been satisfactorily demonstrated that the marbles of these belts are actually the same. Furthermore, Prouty (1946, p. 1156) proposed the name Farragut for the marble in the Concord belt and recommended that the use of Holston be discontinued.

It should be evident from the nature and origin of calcarenite beds that they are likely to have only a local development and meaning. They are the product usually of the concentration of animal debris and therefore may occur at any level and have much the same lithology at each level. They may represent the debris accumulated by the continued occupation of a site by a crinoid-cystid plantation. It is probable that close study of all the marbles will reveal criteria

whereby each may be separated, but the state of our paleontology and sedimentary petrology has not yet reached this desired goal. The name "Holston" in the literature has been applied to calcarenites demonstrably of Lenoir, Lincolnshire, "Athens," Benbolt, and Wardell associations. The name "Murat," which was applied to Lincolnshire calcarenites, was early abandoned in favor of Holston. Because of the uncertainty and inaccuracy of the present application of Holston, the name should be dropped as a stratigraphic term.

Hostler member of Hatter formation.—This member consists of tan-weathering silicious or argillaceous limestone with ripple-marked surfaces. The thickness ranges from 35 to 69 feet. Kay (1944, p. 10) designated the type section as Union Furnace where it overlies the Grazier member of the Hatter formation and underlies the Snyder member of the Benner formation. Hostler rock is so impure that it is never quarried for commercial lime with the result that it is often left as a "rib" or a hanging wall in many of the large quarries. Butts confused this formation with his Lemont member and related it to the Ridley formation because it contains *Maclurites*. Although this correlation with Ridley is believed to be correct, Butts was actually thinking of the Ridley as Lenoir or Chazy, which it is not.

The Hostler member contains the following brachiopods:

- Ancistrorhyncha* sp. = *A. crassa* Cooper
- Ancistrorhyncha* sp. aff. *A. costata* Cooper = *A. costata* Ulrich and Cooper
- **Camarotoechia* sp. cf. *C. plena* (Hall)
- **Campylorthis deflecta* (Conrad) = *Chaulistomella*
- **C. magna* (Schuchert and Cooper) = *Chaulistomella*
- Doleroides* sp.
- Glyptorthis* sp.
- Fascifera subcarinata* Ulrich and Cooper
- **Leptaena* ? sp.
- Öpikina* sp. aff. *inquassa* (Sardeson)
- Öpikina* sp. cf. *Ö. magna* (Butts)
- Öpikina* sp. aff. *Ö. minnesotensis* (N. H. Winchell)
- **Öpikina* sp. aff. *Ö. septata* Salmon
- Pionodema minuscula* Willard
- Pionodema* sp.
- Rostricellula ovata* Cooper
- Sowerbyella* sp.
- Strophomena* sp. aff. *medialis* Butts
- Strophomena* sp.
- Strophomena* sp.

Correlation of Hostler member.—Kay (1944, p. 12) correlates the Hostler member of the Hatter formation with the Benbolt formation of Virginia. This correlation is believed to be incorrect because the formation contains no species in common with the Benbolt. The characteristic *Dinorthis transversa* Willard is not present, nor is the host of other species and genera having affinities with the Arline suite. Actually the fauna of the Hostler has its ties with beds higher than the Benbolt, specifically with the Wardell formation. Wardell ties appear in the *Ancistrorhyncha*, not yet known in the Benbolt, *Fascifera subcarinata*,

abundant *Öpikina* and *Strophomena* like *S. medialis* Butts. Besides having a fauna like that of the Wardell formation, the Hostler member is lithologically reminiscent of the Ridley, equivalent of the Wardell in the Central Basin of Tennessee.

Housum member of Mercersburg formation.—This name was proposed by Craig (1949, p. 732) for the basal member of the Mercersburg formation exposed only in the eastern belts of central Pennsylvania. The type section is in the railroad cut $2\frac{1}{2}$ miles southwest of Marion. The member consists of 67 feet of tan to medium-gray, fine-grained, argillaceous, slabby, cream- to buff-weathering limestone with an interval of dark-gray, thin, crinkly, gray-weathering limestone near the top. The member thins to the northeast. It contains few fossils, but the presence of *Leptaena* (?) sp. cf. *L. charlottae* Winchell and Schuchert was regarded as so important that the member was transferred from the Shippensburg, where it had originally been placed, to the Mercersburg. As shown elsewhere in this monograph, this fossil is a long-ranging one and does not have the significance for correlation given it by some stratigraphers. The few brachiopods recorded from this member are:

**Leptaena* sp. cf. *L. charlottae* Winchell and Schuchert

Lingula sp.

Lingulasma sp.

Öpikina aff. *O. ruedemanni* Salmon

**Sowerbyella* cf. *S. punctostriata* (Mather)

Hurricane Bridge formation.—This name was proposed by Miller and Brosge (1950) for 288 to 368 feet of calcilutite with occasional thin beds of buff shaly mudstone. *Tetradium cellulosum* is abundant in the lower 150 feet. The name is taken from exposures along and near the road southeast of Hurricane Bridge, Hubbard Springs (T.V.A. 170-NW) Quadrangle, Va. Brachiopods are uncommon.

Ancistrohyncha sp.

Strophomena sp.

Zygospira ? sp.

Correlation of Hurricane Bridge formation.—This formation underlies the Woodway formation of Miller which contains fossils of the Wardell and Witten formations and overlies the Martin Creek limestone, a probable Ward Cove equivalent. The Hurricane Bridge formation is thus in the position of the Benbolt formation and part of the Wardell but has the calcilutite facies with abundance of *Tetradium*.

Jacksonburg formation.—This formation in northwestern New Jersey and adjacent Pennsylvania occurs in two physiographic provinces: The Appalachian Valley, and an extension of the New England Upland. In the Appalachian Valley the formation consists of 135 feet of high-grade limestone resting unconformably on the Kittatinny limestone. At the type section the lower 58 feet are faunally different from the upper 77 feet, and the lower Division is separated from the upper by a conglomerate and a faunal change. The lower part

contains *Leperditia* in abundance and was originally assigned to the Black River. Elsewhere the Jacksonburg (R. L. Miller, 1937) attains a thickness up to 300 feet and is transitional to the overlying Martinsburg formation.

The lower division of the Jacksonburg contains *Receptaculites occidentalis* Salter as well as *Leperditia*. Brachiopods found in the Lower Jacksonburg are:

Camarella inornata Weller = *Idiospira inornata* (Weller)

Dalmanella subaequata (Conrad) = *Pionodema subaequata* (Conrad)

Lingula sp. = *Skenidioides* sp.

Rafinesquina alternata (Emmons) = *R. trentonensis* (Conrad)

Scenidium anthonsensis Sardeson = *Skenidioides* sp.

Strophomena conradi Hall and Clarke

Strophomena sp.

This list suggests assignment to lower Trenton rocks such as the Guttenberg member of the Decorah because of the presence of *Rafinesquina* and *Pionodema*. Correlation with the Nealmont of Pennsylvania, the Collierstown formation of Virginia, and the Rockland of New York and Ontario is also possible.

Brachiopods from the upper division are:

Dalmanella subaequata (Conrad) = *Pionodema subaequata* (Conrad)

**D. testudinaria* (Dalman) = *Paucicrura* sp. 2

Dinorthis pectinella (Emmons)

Lingula riciniiformis Hall

Orbiculoidea lamellosa (Hall)

Orthis tricenaria Conrad

Parastrophina hemiplicata (Hall)

**Platystrophia biforata* (Schlotheim) = *Oxoplectia* ?

**Plectambonites sericeus* (Sowerby)

Plectorthis plicatella (Hall)

**P. (Austinella) whitfieldi* (N. H. Winchell)

Rafinesquina alternata (Emmons)

Reuschella americana Cooper

**Rhynchotrema dentata* (Hall)

**R. inaequivallis* (Castelnau)

Schizocrania filosa (Hall)

Strophomena conradi Hall and Clarke

**Strophomena incurvata* (Shepard)

Zygospira nicolleti (Winchell and Schuchert) = *Protozyga nicolleti* (Winchell and Schuchert)

Z. recurvirostris (Hall)

Correlation of upper Jacksonburg formation.—This list is difficult to interpret because of unlikely species listed, but presence of *Reuschella* and *Parastrophina* are links to Oranda and Salona.

Kauffman member of Mercersburg formation.—This formation has its type section in the railroad cut $2\frac{1}{2}$ miles southwest of Marion, Pa. The member consists of 168 feet of platy, bedded limestone lying conformably on the Housum member of the Mercersburg formation and disconformably below the Oranda formation. Craig (1949, p. 734), who named the member, states that it thins to the northeast of the type section. In the western belts the member can be recognized only in a few sections containing Mercersburg metabentonite No. 2.

The Kauffman is thought to correlate with the Centre Hall member of the Nealmont formation. The following brachiopods were identified by Craig (1949, pp. 736, 737):

Dinorthis sp. cf. *D. pectinella* (Conrad)

Doleroides sp. cf. *D. pervetus* (Conrad)

Glyptorthis sp. cf. *G. bellarugosa* (Conrad)

Leptaena sp. cf. *L. charlottae* Winchell and Schuchert = *Limbinurina*

Lingula sp.

Sowerbyella sp. cf. *S. punctostriata* (Mather)

Strophomena 2 sp.

Zygospira recurvirostris (Hall)

Lantz Mills facies of Edinburg formation.—This name is applied by Cooper and Cooper (1946, p. 78) to the cobbly to nodular, buff-weathering limestone well developed near Lantz Mills about 4.6 miles N. 69° W. of Edinburg, Va. As a facies this type of lithology appears at various levels in the Edinburg formation. But on the west side of the Massanutten syncline and western belts it is best developed in the lower part of the formation where it comprises the *Echinosphaerites-Cyrtonotella* and *Nidulites* zones. On the east side of the Massanutten syncline this facies alternates with the black shale and limestone of the Liberty Hall facies. The two fossil zones of the Edinburg formation mentioned above roughly correspond to the Shippensburg formation of Craig (1949) and are the Virginia equivalent of that formation.

Brachiopods taken from the *Echinosphaerites-Cyrtonotella* zone of the Edinburg formation are listed under this heading under the Edinburg formation.

Correlation of lower Lantz Mills facies.—The correlation of this part of the Lantz Mills facies of the Edinburg formation is with the interval from the Effna-Arline to the lower part of the Benbolt. Effna-Arline affinities appear in the presence of *Ptychoglyptus*, *Christiania*, *Scaphorthis*, *Glyptambonites*, and *Cyrtonotella*. *Dinorthis transversa* is a link to the Benbolt.

Brachiopods from the *Nidulites* zone are listed under that heading under Edinburg formation.

Correlation of upper Lantz Mills facies.—This portion of the Edinburg underlies the St. Luke member which is correlated with the Witten and the Rockland formation. The part of the Edinburg with *Nidulites* bridges a long time interval. The fauna, too, is somewhat transitional in having the last remnants of the Benbolt (*Dinorthis transversa*) near the base and elements of the Wardell suite such as *Strophomena* in the upper part.

Lemont member of Carlisle formation.—This member was named by Butts (1918, p. 526) for limestone exposed in the railroad cut a short distance south of Lemont. At this place a species of *Maclurites* is fairly common and was confused by Butts with *M. "magnus"* Leseuer of the Chazy group. Butts thus regarded his Lemont as a part of the Chazy and identified his member elsewhere in Pennsylvania where the rock was shaly and had *M. "magnus."* The type section of the Lemont is actually at the top of the limestone sequence now called Nealmont (Kay, 1944, p. 97). Butts' use of the name Lemont was generally

for a brownish, shaly rock left as a "rib" in quarrying operations to which Kay (1944, p. 10) applied the name "Hostler member of the Hatter formation." Butts' Lemont of the type section is thus part of the Nealmont, and his Lemont outside the type section is generally Hostler.

Lenoir formation.—B. N. Cooper and G. A. Cooper here restrict the name Lenoir to the sequence exhibited at the type locality on the east side of Lenoir City. So restricted, the long sequence containing *Christiania*, originally referred to the Lenoir by many geologists, is excluded. The *Christiania* beds are now called Arline formation. At the type locality the Lenoir contains three zones in ascending order: *Rostricellula* zone, *Valcourea-Mimella* zone, and *Maclurites* zone. In the southeastern belts in Tennessee the *Rostricellula* zone is widespread but is often difficult to find. In places, such as the belt along the base of the Great Smoky Mountains, it occurs in sinks or small masses (the Douglas Lake is an example). It is often a mass of calcarenite abounding in *Rostricellula* and other fossils, as behind the Friends Church at Friendsville.

The biggest and best development of the Lenoir is at Friendsville where each of the zones is well developed and fairly thick.

To the west of the Friendsville area in Tennessee, across the strike of the various belts, the Lenoir changes its lithology and is ultimately cut out. In its changed lithology, the Lenoir appears as a calcarenite well exhibited near Tumbez in Virginia with a basal conglomerate containing *Rostricellula*, and the massive limestones above it contain *Valcourea* and *Mimella*. Here it has been called the Tumbez formation (B. N. Cooper, 1945b, p. 133). The Blackford formation of dolomites, red beds, and conglomerates is equivalent to Tumbez and Lenoir. In the belt along the Cumberland Front the Lenoir is missing; the Blackford facies (Dot formation) there is equivalent to the Hogskin member of the Lincolnshire formation.

Brachiopods identified in the restricted Lenoir are:

Atelelasma variabile Cooper
Camerella triangulata Cooper
Dactylogonia alternata Cooper
Dorytreta ovata Cooper
Hesperorthis tenuicostata Cooper
Macrocoelia nuclea (Butts)
M. plebeia Cooper
Macrocoelia sp. 1

Onychoplectra brevirostris Cooper
Ptychoplectrella glypta Cooper
Rostricellula basalaris Cooper
R. costata Cooper
R. multicostata Cooper
R. varicosta Cooper
Titanambonites praecursor Cooper
Valcourea obscura Cooper

Correlation of restricted Lenoir formation.—The Lenoir formation as restricted contains elements of the Crown Point and Valcour formations of the New York sequence. The *Hesperorthis* is a link to the Valcour, as is *Titanambonites*, which ties the Lenoir to the higher beds. *Onychoplectra* and *Valcourea* are suggestive of the Crown Point formation. The *Mimellas* might relate the Lenoir to either of the New York formations. Actually the Lenoir fauna may be more like that of the Valcour than now realized because description of the fossils of the St. Martin formation will make available Valcour species of *Dactylogonia*, *Mimella*, and other genera not now recorded from the Valcour but definitely present.

Liberty Hall facies of Edinburg formation.—This name was used by Cooper and Cooper (1946, p. 78) for black graptolitic shale and black conchoidally fracturing limestone which interfingers with the Lantz Mills facies of cobbly limestone. The Liberty Hall facies is best developed on the east side of the Massanutten syncline and in the vicinity of Lexington and Natural Bridge, Va. This facies corresponds in the Lexington region to the Liberty Hall formation of H. D. Campbell (1905, p. 445). In general, the Liberty Hall facies disappears to the northeast and is best developed to the southwest.

The following brachiopods have been taken from the Liberty Hall facies:

| | |
|---|---|
| <i>Acanthocrania spinosa</i> Cooper | <i>Laticrura pionodema</i> Cooper |
| <i>Camerella leiorhynchoidea</i> Cooper | <i>Leptobolus</i> sp. 1 |
| <i>Chonetoida virginica</i> Cooper | <i>Leptobolus</i> sp. 2 |
| <i>Conotreta multisinuata</i> Cooper | <i>Lingulella lirata</i> Cooper |
| <i>Cyclospira quadrata</i> Cooper | <i>Oxoplectra holstonensis</i> Willard |
| <i>Ectenoglossa nymphoidea</i> Cooper | <i>Paucicrura virginica</i> Cooper |
| <i>Elliptoglossa ovalis</i> Cooper | <i>Perimecocoelia semicostata</i> Cooper |
| <i>E. rotundata</i> Cooper | <i>Petrocrania</i> sp. 2 |
| <i>Eoplectodonta</i> sp. 1 | <i>Phragmorthis buttsi</i> Cooper |
| <i>Glyptambonites glyptus</i> Cooper | <i>Ptychoglyptus virginianensis</i> Willard |
| <i>Kullervo parva</i> Cooper | <i>Skenidioides costatus</i> Cooper |

Correlation of Liberty Hall facies.—The black limestone interfingers with Lantz Mills facies. The faunal list, with its many Botetourt and Arline elements, shows that the lower Liberty Hall, like lower Rich Valley, contains lenses or fingers of limestone with Arline fossils. The Liberty Hall facies also fingers with beds having Wardell affinities.

The Whitesburg formation of East Tennessee is the same type of facies as the Liberty Hall but seems not to have as great a stratigraphic range as the Liberty Hall. It seems to include Benbolt equivalents, but nothing higher was definitely identified. It is interesting to note that the rocks on the east side of the Massanutten syncline in northern Virginia are mostly of the Liberty Hall facies. On Opequon Creek east of Winchester fingers of Martinsburg lithology appear in the Liberty Hall. This suggests that eastward Martinsburg lithology would replace Liberty Hall if unmetamorphosed sequences were preserved. Such fingers also appear in the Edinburg.

Lincolnshire formation.—This formation was named by Cooper and Prouty (1943, p. 863) for exposures in the quarry on Lincolnshire Branch west of Five Oaks, Va. It consists of dark, granular, cherty limestone ranging in thickness from 40 to 100 feet. The formation is widespread in Virginia and the western belts of East Tennessee. It is not known in the belts south of the Saltville fault. The formation generally overlies the Five Oaks formation or formations subjacent to the Five Oaks. It is overlain by the Ward Cove formation or its equivalents. In the Clinch Mountain and adjacent belts to the north, the Lincolnshire appears to be displaced entirely or in part by the Hogskin member. In these areas two members are recognized: Eidson cherty limestone and Hogskin shale.

The Lincolnshire is the "Lenoir" of northern Virginia as mapped and described by Butts. The formation extends in a northeasterly direction nearly to the

Virginia–West Virginia line. In this direction the formation may be partially equivalent to the New Market formation of Maryland and West Virginia.

Brachiopods are abundant in the Lincolnshire formation:

Atelelasma decorticatum Cooper
Camerella elliptica Cooper
Cyrtonotella minor Cooper
Dactylogonia obtusa Cooper
D. prona (Willard)
Dinorthis atavoides Willard
Hesperorthis biconvexa Cooper
H. longirostra Cooper
H. multicostata Cooper
Macrocoelia duplistriata Cooper
M. platys Cooper
Mimella laticardinia Cooper
M. tumida Cooper
Mimella sp. 3
Multicostella gerontica Cooper
M. plicata Cooper

M. semisulcata Cooper
Oligorhynchia subplana Cooper
Oxoplecia eidsonensis Cooper
O. recta Cooper
Paurorthis magna Cooper
Pionomena neumani Cooper
Plectocamara aseptata Cooper
Protozyga rotundiformis Cooper
Rhipidomena tenuitesta (Willard)
Sowerbyella medioplicata Cooper
Sowerbyites gildersleevei Cooper
S. subnasutus Cooper
S. triseptatus (Willard)
Valcourea sp. 1
Valcourea sp. 2

Correlation of Lincolnshire formation.—The correlation of this formation has caused considerable difficulty because it has obvious similarity to the New York Chazy but also equally strong relationships with post-Chazy rocks. Kay (1948, p. 1405) correlates the Lincolnshire with the Chazy (Valcour) of New York on the “bases (sic) of stratigraphic position, the presence of the overlying regional unconformity and fossils not known in younger beds.” The Lincolnshire formation contains equally strong post-Chazy faunal elements in the form of *Dinorthis*, *Sowerbyites*, *Cyrtonotella*, *Oxoplecia*, and *Sowerbyella*. Not one of these genera has yet been cited from the Valcour fauna, the fossils of which are very like those of the Crown Point formation rather than the higher Black River types. The only strictly Chazy types in the Lincolnshire are *Multicostella* and *Valcourea*. Kay does not record the fossils on which he relies and which may not be brachiopods.

Prouty (1946, p. 1152) correlates the Lincolnshire with the high Lenoir (*Christiania* beds), here assigned to the Arline formation. This correlation is untenable because the Lincolnshire underlies the Effna, Botetourt, or basal Edinburg, all of which are equivalents of the Arline formation and contain *Christiania*. No trace of the Lincolnshire (or Elway) formations has been found in the Saltville fault block and the Friendsville region.

Little Oak formation.—The Little Oak formation of Alabama was named by Butts (1926, p. 112) but has long been misunderstood and has never been satisfactorily correlated. It consists of thick-bedded, dark, nodular limestone with nodular chert. The maximum thickness in Cahaba Valley is 500 feet. In the neighborhood of Ragland, St. Clair County, Ala., it contains two layers of metabentonite. Near Siluria the thinned edge of the Little Oak rests on black shale (Columbiana formation). To the north along Cahaba Valley, the Little Oak thickens enormously and rests on the Lenoir formation. It is here suggested that the relationships in Cahaba Valley are those of a replacement be-

tween Little Oak limestone and the black Columbiana shale. At Pratt Ferry only the Columbiana black shale is present, except for the upper 20 feet of the "Lenoir," which contains Little Oak fossils and the thin Pratt Ferry formation.

Brachiopods are abundant in the Little Oak formation:

| | |
|--|--|
| <i>Ateleasma</i> sp. | <i>Öpikina</i> sp. 4 |
| <i>Bimuria buttsi</i> Cooper | <i>Orthambonites buttsi</i> (Schuchert and Cooper) |
| <i>Christiania subquadrata</i> (Hall) | <i>O. mostellerensis</i> Cooper |
| <i>Dactylogonia geniculata</i> Ulrich and Cooper | <i>O. tennesseensis</i> Cooper |
| <i>D. obsoleta</i> (Butts) | <i>Oxoplecia gibbosa</i> Cooper |
| <i>Eremotoechia alabamensis</i> Cooper | <i>Paurorthis fasciculata</i> Cooper |
| <i>Glyptorthis concinnula</i> Cooper | <i>Plectorthis australis</i> Cooper |
| <i>Glyptorthis</i> sp. 3 | <i>Polytoechia</i> ? <i>oakensis</i> Butts |
| <i>Isophragma extensum</i> Cooper | <i>Productorthis americana</i> Cooper |
| <i>I. sulcatum</i> Cooper | <i>Skenidioides platys</i> Cooper |
| <i>Laticrura heteropleura</i> Cooper | <i>Sowerbyella varicostellata</i> Cooper |
| <i>Leptellina delicatula</i> (Butts) | <i>Taphrorthis emarginata</i> Cooper |
| <i>L. tennesseensis</i> Ulrich and Cooper | <i>Titanambonites amplius</i> (Raymond) |
| <i>Lingulella</i> sp. 3 | <i>T. convexus</i> Cooper |
| <i>Macrocoelia ornata</i> Cooper | <i>Titanambonites</i> sp. 1 |
| <i>Multicostella fasciculata</i> (Butts) | <i>Valcourea ventro-carinata</i> (Butts) |
| <i>Murinella</i> sp. 3 | <i>Zygospira</i> ? <i>matutina</i> Cooper |

Correlation of Little Oak formation.—This fauna was originally thought to be related to the Oranda fauna (=Upper Chambersburg), but later Ulrich (1930, p. 59) revised his views and stated that the Little Oak fauna is unlike any other Blount fauna except that of the Holston marble. According to Ulrich the fauna has a general resemblance to that of the upper Lenoir and through that fauna with the middle Chazy of the Champlain Valley. In his correlation chart Ulrich (1930, p. 73) places the Little Oak on top of the Blount group but under the Lowville.

The Little Oak fauna is actually almost identical generically with that of the Arline formation which is the cobbly limestone equivalent of the Athens formation (=Columbiana) of Tennessee. The rare genus *Eremotoechia* is known only from these two formations and the Pratt Ferry formation, which is also a manifestation of the Little Oak (see below). The Little Oak, like the Arline, is also correlated with the Stinchur-Balclatchie limestones of the Girvan district of Scotland. The Little Oak is also correlated with the Effna formation and the Lower Edinburg formation of Virginia. The Little Oak appears to be equivalent to the graptolitic Columbiana shale which contains *Nemagraptus*.

It is important here to state the conditions involving the Little Oak formation at Pratt Ferry. At this place Lenoir, with big *Maclurites*, is overlain by 20 feet of massive limestone that weathers with a white crust. *Christiania* is abundant in this limestone together with *Titanambonites* and *Isophragma*, all Arline-Little Oak fossils. This bed must be separated from the Lenoir with which it has been mapped. The Pratt Ferry formation overlies the *Christiania* bed and is thus within the Little Oak. It is overlain by Columbiana shale with *Nemagraptus*.

Long Savannah formation.—In belts northwest of the White Oak Moun-

tain fault in southern Tennessee, Georgia, and Alabama, the Lower Ordovician (Canadian limestones and dolomites) are succeeded by red beds and buff earthy limestone 50 to 175 feet thick, which resemble closely the Blackford red beds of Virginia and Tennessee and parts of the Attalla formation of Alabama. The basal layers of the Long Savannah formation contain detrital chert and some minor quartz sand. There are indications that the formation possibly ranges as high as Peery and Rob Camp formations. It is also possible that the base, although lithologically identical with the basal Blackford beds, is considerably higher in the column than the latter. No fossils have been taken from the formation. The type section is exposed along the Mahan Gap Road, but the name is taken from Long Savannah Creek just northeast of Snow Hill, Snow Hill (T.V.A. 212-NE) Quadrangle.

Loysburg formation.—As described by Kay (1944, pp. 1-6), this formation in central Pennsylvania consists of two members: The "Tiger-striped" and the Clover. The formation lies between the Lower Ordovician Bellefonte formation and the Hatter formation. The "Tiger-striped" consists of buff-weathering dolomite which penetrates and channels the Bellefonte limestone. In addition to this lithology are limestones, laminated dolomites, and thin beds of ostracode-bearing limestone. This part of the sequence has never been studied in detail, but it is possible that the dolomites and interbedded limestones between the Clover and Lower Ordovician are to be correlated with the Row Park formation. The Loysburg, like the Blackford of Virginia, may be of different age in different places.

The Clover member is a sublithographic limestone mentioned under that heading above. No brachiopods have been reported from the Loysburg formation.

Mahan formation.—(B. N. Cooper and G. A. Cooper.) This name is proposed for 200 feet of ribbon-banded to thick-bedded dove-gray calcilutite, the lower half of which is characteristically studded with plates and nodules of black chert. The upper part of the formation is even-bedded *Tetradium*-bearing calcilutite with numerous shaly interbeds containing *Pionodema* and *Ancistro-rhyncha*. The Lower beds contain species of *Strophomena*, like those in the Ridley limestone of the Central Basin of Tennessee, and *S. inspeciosa* Willard. The Mahan formation succeeds a body of red dolomitic mudstone and interbedded buff earthy limestones, the Long Savannah formation. The top of the Mahan is defined at the type locality by a Moccasin-type red mudstone—one of several red intercalations in a thick succession of ribbon-banded *Camarocladia*-bearing limestones. The type section is along Mahan Road, Snow Hill (T.V.A. 112-NE) Quadrangle, about 1,900 feet west-northwest of the intersection with Tennessee Highway 60, Hamilton County, Tenn. The Mahan formation is believed to include mainly beds of Benbolt and Pierce-Ridley affinities, but possibly Peery and Rob Camp formations of southwestern Virginia are represented in the lower part. (See Benbolt and Pierce-Ridley formations for lists of fossils.) The *Tetradium*-bearing beds of the Mahan are lithologically indistinguishable from Hurricane Bridge formation as developed at Hagan, Va., and Speedwell, Tenn.

Marcem formation (B. N. Cooper and G. A. Cooper, new formation).—

Along the northwest base of Clinch Mountain west of Gate City the Lincolnshire formation is underlain by a section with conglomerate at the base, succeeded by light-gray to pink massive calcarenite containing worn colonies of *Billingsaria*. Minor portions of shale, mudstone, and calcilutite may be present. *Dinorthis holdeni* (Willard) occurs in the upper part. The formation ranges from 120 to 300 feet thick. The basal beds contain *Rostricellula basalaris* Cooper. The formation is thus a calcarenite equivalent of the Elway and Tumblez. The formation name is from Marcem Quarry, 2 miles west of Gate City, Va.

Martin Creek formation.—Miller and Brosge (1950) proposed this name for dark-gray and brown limestone smelling of oil, with chert nodules and tan cryptocrystalline limestone with abundant chert nodules in the upper part. The thickness is 40 to 180 feet. It is named for exposures at the mouth of Martin Creek, Back Valley (T.V.A. 161-SE) Quadrangle, Virginia-Tennessee. The following brachiopods were identified:

Camerella sp.

Rhipidomena tenuitesta (Willard)

Multicostella cf. *M. saffordi* (Hall and Clarke)

Schizambon sp.

The formation is uncertainly correlated with part of the Ward Cove formation.

Martinsburg formation.—This formation consists of a thick mass of silty and arenaceous shale overlying the great body of Middle Ordovician limestones in the Appalachian Valley. The base of the formation, as exhibited near Green Mount Church, about 5 miles north of Harrisonburg, Va., contains some thin beds of limestone and has the fauna of the Salona formation of Pennsylvania. The higher Martinsburg formation contains Eden and Maysville fossils, but only the basal portion is of concern in this monograph. In southwestern Virginia and East Tennessee the base of the Martinsburg formation contains thin-bedded limestones abounding in *Dinorthis* and a large *Sowerbyella*. This part of the section is correlated with the Curdsville formation of Kentucky. Brachiopods are abundant at the base of the formation in most areas.

Brachiopods taken from the lower Martinsburg (Salona) near Green Mount Church, Broadway (15') Quadrangle, Va.:

Colaptomena leptostrophoidea Cooper

Parastraphina sp. 1

Cyclospira quadrata Cooper

Paucicrura subplana Cooper

Cyphomena grandis Cooper

Petrocrania trentonensis (Hall)

Dalmanella sculpta Cooper

Phragmorthis crassa Cooper

Eoplectodonta alternata (Butts)

Plectrothis ponderosa Cooper

Laticrura magna Cooper

Skenidioides elongatus Cooper

Leptaena ordovicica Cooper

Sowerbyella cava Cooper

Orthambonites bielsteini Cooper

S. eximia Cooper

Oxoplectia globularis Cooper

Strophomena bellilineata Cooper

Parastraphina hemiplicata (Hall)

Brachiopods from the lower Martinsburg (Curdsville) in southwestern Virginia and Tennessee:

Dalmanella rara Cooper

Dinorthis pectinella (Emmons)

Hesperorthis tricenaria (Conrad)

Omniella fertilis (Ulrich)
Rafinesquina trentonensis (Conrad)
Rhynchotrema sp.
Sowerbyella curdsvillensis (Foerste)
Zygospira sp.

Brachiopods from *Simuites* zone at base of Martinsburg in Pennsylvania listed by Bassler (1919, p. 165) are:

Christiania lamellosa Bassler = *Bimuria lamellosa* (Bassler)
Dalmanella edsoni Bassler = *Reuschella americana* Cooper
D. testudinaria (Dalman) var. = *D. sculpta* Cooper
Leptaena tenuistriata Sowerby var. = *L. ordovicica* Cooper
Leptobolus ovalis Bassler = *Elliptoglossa ovalis* (Bassler)
 **Lingula riciniiformis* Hall = ?
Strophomena sculpturata Bassler = *S. ? sculpturata* Bassler
Triplecia (Cliftonia) *simulatrix* Bassler = *Oxoplecia simulatrix* (Bassler)

Meadow marble.—This name is applied (C. H. Gordon, 1924, p. 39) to a calcarenite lens located southwest of Friendsville, Tenn., which is near the base of the Sevier formation. It contains numerous fossils, especially brachiopods, but the specimens are difficult to identify accurately because of poor preservation. The genera present in the formation are listed below.

| | |
|-------------------------|------------------------|
| <i>Cyrtonotella</i> sp. | <i>Paurorthis</i> sp. |
| <i>Glyptorthis</i> sp. | <i>Protozyga</i> sp. 1 |
| <i>Oxoplecia</i> sp. | <i>Sowerbyella</i> sp. |

Mercersburg formation.—This formation was proposed by Craig (1949, p. 731) for "dark grey, fine-grained, thin crinkly- and thick evenly-bedded blue-grey weathering limestones with an interval of tan to medium-grey, slabby, buff-weathering limestone at the base." The type section is the railroad cut 2 miles southwest of Marion, Pa. The formation thins from 235 feet at the type section to 155 feet at Middle Spring to the northeast, and to less than 100 feet in the belts to the northwest. The formation is composed of the Housum and Kauffman members. The brachiopods reported by Craig are listed under the member names.

Moccasin formation.—This name is applied to the red and yellow mudrock overlying the Witten formation and underlying the Eggleston formation. This rock is widespread in southwestern Virginia and East Tennessee. In the western belts occasional fingers of calcilutite appear. In Sequatchie Valley, Tenn., equivalents of the Moccasin are referred to Lebanon and Carters limestones.

Pseudolingula luttrellensis Cooper
Zygospira lebanonensis Cooper

Mosheim formation (=facies).—This is really a facies rather than a formation and has been widely misidentified as a formation. The name should be used only for calcilutites associated with the restricted Lenoir formation in the southeastern belts and their equivalents. At the type section, the formation overlies the Knox dolomite but underlies Lenoir lithology. Northeast of Friendsville typical Mosheim appears, sandwiched between beds with typical Lenoir

lithology. Behind the Friends Church in Friendsville, Mosheim is also underlain by calcarenites abounding in typical Lenoir species. Thus the Mosheim is a part of the Lenoir, but it is discontinuous and appears at different levels in the Lenoir. This type of rock containing a fairly definite molluscan fauna can be seen as far southwest as the Cahaba Valley of Alabama, and to the northeast it is known in south-central Virginia, as at Marion where it overlies calcarenites containing fossils, in both places like those behind the Friends Church. The Mosheim fauna contains few brachiopods, but the few that have been found are unusual types:

Rostricellula basalaris Cooper

Stenocamara bicostata Cooper

S. perplexa Cooper

Murat formation.—This is also a facies rather than a formation and is lithologically like the "Holston" of Tennessee. It is not, however, of the same age as the Holston and is more usually a gray limestone, particularly in its type region. The Murat is a calcarenite equivalent of the dark, cherty Lincolnshire formation. Fingers of the Lincolnshire can be seen in the calcarenite near Lexington, also in localities on the Pressmens Home Quadrangle, Tenn. Numerous brachiopods have been taken from the formation but, like those of the so-called Holston limestone and Meadow marble, are difficult to identify because of poor preservation.

Atelelasma decorticatum Cooper

Dactylogonia marmorata Cooper

Dinorthis atavoides Willard

Glyptomena bella Cooper

Mimella laticardinia Cooper

Pseudobolus gibbosus (Willard)

Schizambon hirsutum Cooper

Sowerbyites triseptatus (Willard)

Nealmont formation.—The name was proposed by Kay (1944, p. 97) for a sequence of limestones exposed in all the belts of central Pennsylvania. It consists of three members from the base up: Oak Hall, Centre Hall, and Rodman. The formation is composed of limestone and is correlated with the lower part of the Trenton. The brachiopods are listed under the separate members except for those listed below for which data relating them to the members are lacking:

Ancistrohyncha australis (Foerste)

Craniops trentonensis (Hall)

Pionodema sulcata Cooper

Zygospira elongata Cooper

New Market formation.—This name was proposed by B. N. Cooper and G. A. Cooper (1946, p. 71) for calcilutites overlying the Knox formation but underling the Lincolnshire formation. The type section is in the Madden Quarry 0.65 miles west of New Market, Va. To the northeast of the type section the New Market thickens and its stratigraphy becomes complex. Neuman (1951, p. 286) amplified the New Market formation and identified the so-called "Lowville" underlying the Chambersburg formation (Shippensburg of Craig) as New Market. Cooper and Cooper (1946, p. 69) identified the New Market formation underneath an 800-foot sequence of "Stones River" which immediately underlies the "Lowville." The New Market of Cooper and Cooper near Marion, Pa., fingers at the base with dolomites, as it does at New Market.

Neuman named the 800-foot sequence of "Stones River" the Row Park formation. Cooper and Cooper had previously identified this sequence as Whistle Creek on the basis of contained fossils. Below the New Market of Cooper and Cooper, Neuman discovered granular limestone containing abundance of *Rostricellula*.

The seemingly conflicting identifications of New Market by Cooper and Cooper and Neuman can be interpreted as a facies condition.

It is postulated here that both identifications of New Market are correct, but that the Row Park is a partial facies of the New Market and also the Whistle Creek. Neuman shows New Market lithology interfingering with *Maclurites*-bearing limestones. The same situation can be seen at Wilson, Md., and in the big quarry at Pinesburg, Md. Thus the New Market is sandwiched between *Rostricellula* beds of the Row Park at the base and the main body of the Row Park. It interfingers with the main mass of the Row Park. New Market also overlies Row Park, as it does near Marion.

A more moot point is the suggestion by B. N. Cooper and G. A. Cooper (1946, p. 70) that New Market (their "Lowville" facies) interfingers also with the Lincolnshire which overlies New Market at its type section. The Lincolnshire thins to the northeast in the same direction in which the New Market thickens. Lincolnshire is not certainly known in Maryland, but a tongue of dark limestone on the New Market in a quarry at Wilson is tentatively identified as Lincolnshire.

The facies shifts described above are like those that occur elsewhere in the Appalachians. In fact the whole of the Appalachian sequence treated herein, except the Martinsburg, passes into calcilitites of one kind or another.

Few brachiopods have been taken from the New Market:

Pionomena neumani Cooper

Rostricellula elliptica Cooper

Oak Hall member of Nealmont formation.—This member was defined by Kay (1944, p. 97) for exposures on Pennsylvania Highway 322, 1 mile west of Tusseyville, Pa. The Oak Hall is the lowest member of the Nealmont formation and consists of heavy-bedded limestone about 60 feet thick. The Oak Hall lies unconformably over the Valentine formation. At Bellefonte, Pa., the Oak Hall is absent from the Nealmont formation, except for channels in the underlying limestone.

Ancistrorhyncha sp. = *A. australis* (Foerste)

Camarotoechia sp. = *Rostricellula* sp.

Leptaena (?) sp. cf. *L. charlottae* Winchell and Schuchert = *Bellimurina*

Leptaena sp.

Zygospira recurvirostris (Hall)

Ooltewah formation (B. N. Cooper and G. A. Cooper).—This formation, named from Ooltewah, Hamilton County, Tenn., consists of 250 to 600 feet of ribbon-banded *Camarocladia*-bearing limestone with numerous intercalations of red Moccasin-type mudstone and fewer interbeds of buff shaly limestone over-

lying the Long Savannah formation and overlain by the Bays formation. The lower half of the formation contains thin, shaly layers packed with *Ancistro-rhyncha*, *Pionodema*, and *Sowerbyella*. The upper beds contain abundant *Doleroïdes*, *Pionodema*, *Öpikina*, *Hesperorthis*, and *Chaulistomella*. The Ooltewah limestone is linked with the Ridley and Lebanon limestones of the Central Basin of Tennessee, with the Witten and Wardell formations of the middle belts of southwestern Virginia, and with the Hardy Creek-Ben Hur-Witten and Upper Dryden formations of Powell Valley, Lee County, Va. The type section is along Mahan Gap Road and extends for a quarter of a mile or more on either side of State Highway 60, Snow Hill (T.V.A. 112-NE) Quadrangle, Hamilton County, Tenn. The following brachiopods in addition to those recorded above also occur:

Fascifera subcarinata Ulrich and Cooper
Rostricellula ovata Cooper

Strophomena grandimusculosa Cooper
S. inspeciosa Willard

Oranda formation.—This name was proposed by Cooper and Cooper (1946, p. 86) for the upper 30 or more feet of the old Chambersburg formation which is lithologically and faunally very distinctive. The name is taken from a hamlet about 3.5 miles northeast of Strasburg, Va., and the type section is on Virginia State Highway 55, about 0.4 mile west of its junction with U. S. Highway 11 in the north outskirts of Strasburg.

Lithologically the Oranda in many parts of Virginia is a calcareous, fine-grained, dirty sandstone. Fossils are numerous and the matrix is ideal for dissolving the shells out of the rock to produce molds of great fidelity (see illustrations of *Eoplectodonta alternata* and *Strophomena bellilineata*). The sandy character of the formation makes it resistant and thus easily recognized throughout its range. The formation has been identified in Maryland and southern Pennsylvania, but in the latter region it becomes somewhat shaly and contains thin beds of dark limestone.

In the vicinity of Strasburg and along that belt for miles the Oranda maintains its arenaceous character. In the vicinity of Green Mount Church, however, about 4 to 5 miles north of Harrisonburg, Va., the formation contains many thin layers of limestone and suggests a passage, in this direction, to a more limy character.

The Oranda formation has elements of the Kimmswick limestone of Missouri, the Salona of Pennsylvania, and parts of the Trenton of New York. In the vicinity of Lexington and Natural Bridge, Va., the Oranda has not been identified, but its place in the section is occupied by the Collierstown formation which is completely unlike the Oranda lithologically and faunally. It is interesting to note that the dark shales under the Eureka quartzite in central Nevada contain a fauna almost identical in generic composition to the Oranda formation of Virginia.

Brachiopods of the Oranda formation:

Bilobia hemispherica Cooper
Bimuria lamellosa (Bassler)
Chaulistomella sp. 2
Christiania auriculata Cooper

Cristiferina cristifera Cooper
Cyphomena homostriata (Butts)
Dalmanella costellata Cooper
Elliptoglossa ovalis (Bassler)

Eoplectodonta alternata (Butts)
E. ? triradiata (Butts)
Furcitella plicata Cooper
Glyptambonites musculosus Cooper
Hesperorthis virginienensis Cooper
Laticruva magna Cooper
Leptaena ordovicica Cooper
Leptellina abbreviata Cooper
Lingulasma compactum Cooper
Lingulasma sp. 1
Nicolella strasburgensis (Butts)
Orbiculoidea linnwillensis Cooper
Orthambonites bielsteini Cooper

O. multicostellatus Cooper
Oxoplecia simulatrix (Bassler)
Parastrophina sp. 2
Paterula perfecta Cooper
Ptychopleurella sulcata Cooper
Rafinesquina planulata Cooper
Reuschella americana Cooper
Schizotreta microthyris Cooper
Skenidioides rectangulatus Cooper
Sowerbyella cava Cooper
S. eximia Cooper
Strophomena bellilineata Cooper

Correlation of Oranda fauna.—Perhaps the most striking feature of this fauna is its close similarity generically to the faunas of the Arline, Effna, Pratt Ferry, and lower Edinburg formations. The relationship to the Stinchur-Balclatchie formation of the Girvan district, Scotland, is also striking. It seems obvious that the Oranda fauna is a recurrence of the Arline fauna but with modifications that give it the stamp of the Trenton. These younger elements among the brachiopods are *Strophomena*, *Rafinesquina*, *Dalmanella*, *Leptaena*, *Parastrophina*, and *Furcitella*. The latter is similar to *F. schofieldi* of the Prosser of the Mississippi Valley.

Kay (1948, p. 1402) places the Oranda opposite the Shoreham member of the Sherman Fall formation in his correlation table. The Oranda distinctly underlies the zone of abundant *Cryptolithus* trilobites although this trilobite also occurs in it. *Cryptolithus*, however, is a rare fossil in the Oranda. *Reuschella* is another Sherman Fall guide fossil, but the Virginia representative of this genus is clearly a different species from the Vermont *R. edsoni*. It is the writer's belief that the Oranda formation, by virtue of its position, is pre-Sherman Fall.

The Oranda formation is also closely related to the Prosser formation because of the presence of *Echinosphaerites* and the brachiopod *Furcitella*. In the Appalachians the Oranda is directly referable to the Rodman formation of Butts.

Ottosee formation (=facies).—This is a facies ranging in age from the Hogskin member of the Lincolnshire formation through the Wardell formation. As applied by some Appalachian workers the name has been used for any of the yellow-weathering shales regardless of age. The name is also applied to cobbly limestone in the western belts of Virginia and an assortment of other rocks. The type section is at Chillhowee Park in Knoxville, and this part of the section is probably equivalent to the Benbolt formation. The name is better dropped from the Appalachians and is therefore not used in this monograph.

Paperville formation (B. N. Cooper and G. A. Cooper).—This unit comprises a thick succession of gray siltstones, black graptolitic shales and interbedded black limestones, and brown-weathering calcareous sandstones which Keith mapped as Athens in southeastern belts of the Appalachian Valley in Tennessee. These beds form the lower division of a buff-weathering shale-siltstone-sandstone succession totaling several thousand feet in thickness, succeeding the thin

but persistent Fetzner formation. The name is taken from Paperville, near Bristol, Bristol (T.V.A. 206-SW) Quadrangle, where the shales are well exposed. The type section is along Steele Creek, near Paperville, and has been described by Decker (1952, pp. 39-47), who collected representatives of many well-known Normanskill graptolites from these beds. The Paperville shales are capped by the ridge-making calcareous brown-weathering sandstones of the "Tellico" formation. Few brachiopods are known:

Ectenoglossa nymphoidea Cooper

Obolus biconvexa Cooper

Peery formation.—This name was proposed by Cooper and Prouty (1943, p. 863) for a sequence lying between the Ward Cove and Benbolt formations. It consists of a lower cherty limestone, thin-bedded and dark gray, weathering to ash gray. The upper part of the formation is a dove-gray calcilutite. The lower part averages 30 feet thick, but the upper part is usually less than 50 feet thick although it reaches 140 feet at one locality. The best development is northwest of Clinch Mountain. The formation is also present on the southeast side of Clinch Mountain but is usually less than 20 feet thick. On this side of Clinch Mountain the Peery overlies Rich Valley limestone but underlies Benbolt shale.

In the Peery, on the northwest side of Clinch Mountain, fossils are common but poorly preserved in the lower part; they are uncommon and poorly preserved in the upper part. B. N. Cooper reports, with additions of new forms, the following brachiopods:

Ancistrorhyncha crassa Cooper

Mimella sp.

Multicostella sp.

Sowerbyella aequistriata (Willard)

S. delicatula Butts = ? *Leptellina delicatula* (Butts)

S. cf. S. negritus (Willard)

Sowerbyella sp.

Sowerbyites sp.

Strophomena fasciculata Cooper

S. "filitexta" (Hall) = *S. basilicoidea* Cooper

S. tenuitesta Willard

Pelham limestone.—This is a broad name that is nearly equivalent to Chickamauga limestone because it embraces the interval from the top of the Knox to the Clinton. The name was long neglected while Chickamauga was becoming entrenched in the literature. Actually neither name now has any value because the Chickamauga sequence of Georgia and the Pelham of Alabama can be divided into several formations ranging in age from Marmor to Trenton or higher.

Pinesburg member of Shippensburg formation.—This name was proposed by Craig (1949, p. 718) for 140 feet of cobbly and slabby limestone. The type section is on the south side of U. S. Highway 30, 1 mile S. 70° W. of St. Thomas, Pa., although the name is taken from Pinesburg Station in Maryland. The lower part of the member is of platy-weathering limestone, the middle part (73 feet at type section) of cobbly limestone, and the upper 36 feet of dark-gray platy

or slabby limestone. In the eastern belts the member attains a thickness of 238 feet, but it thins to 21 feet near Spring Run; it thickens again to the west and is 41 feet thick in Blacklog Valley. *Echinosphaerites* is abundant in the lower part of the member and *Nidulites* in the upper part. Brachiopods are numerous:

- Bilobia virginiensis* Cooper
- Bimuria parvula* Cooper
- **Camerella* sp. cf. *C. varians* Billings
- Cyphomena angulata* Cooper
- Dinorthis transversa* Willard
- **Doleroides* (?) sp.
- Glyptoglossa cavellosa* Cooper
- Glyptorthis* sp. cf. *G. bellarugosa* (Conrad) = *G. equiconvexa* Cooper
- **Hesperorthis* sp. cf. *H. tricenaria* (Conrad)
- Leptaena* sp. = *L. ordovicica* Cooper
- **Leptellina* (?) sp. cf. *L. elegantula* Butts
- Lingula* sp.
- Lingula* sp. 10
- Lingulasma* sp. 2
- Mimella* sp.
- **Multicostella* sp.
- Öpikina bellula* Cooper
- **Öpikina* sp. cf. *Ö. ruedemanni* Salmon
- Öpikina* sp. cf. *Ö. wagneri* (Okulitch)
- Orthambonites bielsteini* Cooper
- O. rectangulatus* Cooper
- Oxoplectia* aff. *O. calhouni* Wilson = *O. magnaplicata* Cooper
- **O. simulatrix* (Bassler)
- **Parastrophina* sp. cf. *rotundiformis* (Willard)
- Paurorthis ponderosa* Cooper
- Plectocamara magna* Cooper
- Plectorthis* sp. 1
- Protozyga* sp.
- Pseudolingula* sp. 1
- Resserella* sp. = *Paucicrura matutina* Cooper
- Scaphorthis kayi* Cooper
- **Skenidium* (?) sp. cf. *S. anthonense* (Sardeson) = *Skenidioides obtusus* Cooper
- S. aequicostellata* Cooper
- **Sowerbyella* sp. cf. *S. acquistriata* (Willard) = *S. aequicostellata* Cooper
- Sowerbyella* sp. cf. *S. alternata* Butts = *Eoplectodonta* ? *dubia* Cooper
- "*Sowerbyella*" sp. cf. "*S.*" *pisum* (Ruedemann) = *Bilobia virginiensis* Cooper
- Strophomena* sp.
- Strophomena* sp. 1
- Strophomena* sp. 2

Correlation of Pinesburg member.—The lower part of the Pinesburg member is its most fossiliferous part. This contains the *Echinosphaerites* zone and numerous representatives of the *Cyrtonotella* zone of the Edinburg formation of Virginia. The upper boundary of the Pinesburg member has not yet been identified in Virginia.

Poteet formation.—Miller and Brosge (1950) proposed this name for 45 to 97 feet of gray-brown and tan, fine-grained, heavy-bedded limestone named from

exposures along the lane north of Poteet Ford, Ben Hur (T.V.A. 170-NE) Quadrangle, Va.-Tenn. A zone of calcarenite 7 to 8 feet thick (Yellow Branch member) occurs near the base. The zone is well exposed on the road along Yellow Creek on the south-central margin of the Rose Hill (T.V.A. 161-NE) Quadrangle. Brachiopods are mostly from the calcarenite near the base and are listed under the heading of Yellow Branch member of the Poteet formation.

Correlation of Poteet formation.—This formation underlies the Rob Camp formation and overlies the Dot formation. The latter belongs to the Blackford facies here, a probable partial equivalent of the Lincolnshire formation. The Poteet is thus probably related to the Ward Cove formation.

Pratt Ferry formation.—This name is here proposed (B. N. Cooper and G. A. Cooper) for the limestone at the base of the black Columbiana shale 0.2 mile southeast of Pratt Ferry. Widening and paving of the road at this locality has resulted in a fine exposure. The rock is also well exposed in the woods on the east side of the road. About 8 feet of somewhat bituminous calcarenite are exposed in layers varying in thickness up to 4 inches or more. This is the only exposure of the formation known in Alabama. It overlies heavy-bedded gray limestone mapped as Lenoir limestone but which contains the *Christiania* fauna of the Little Oak (see Little Oak). The Pratt Ferry is overlain by black shale with *Nemagraptus* and other graptolites of that zone.

The formation abounds in fossils. Trilobites are numerous, particularly *Telephus*, *Trinodus*, and ceraurids. Brachiopods are abundant and include a variety of inarticulate genera as well as a rich representation of articulates. Treatment with acetic acid yields a harvest from this limestone. Many bizarre and unusual genera are now known from this formation:

Acanthambonia minutissima Cooper

Anisopleurella tricostellata Cooper

Bellimurina sulcata Cooper

Bimuria siphonata Cooper

Christiania subquadrata (Hall)

Conotreta apicalis Cooper

C. concentrica Cooper

C. depressa Cooper

C. gigantea Cooper

C. multisinuata Cooper

Craspedelia marginata Cooper

Cyclomyonia peculiaris Cooper

Dictyonites perforata Cooper

Diorthelasma parvum Cooper

Elasmothyris concinnula Cooper

Ellioglossa ovalis Cooper

Eoconulus rectangulus Cooper

Ephippelasma minutum Cooper

Eremotoechia silicica Cooper

Glossella papillosa Cooper

Glyptambonites glyptus Cooper

Glyptorthis glypta Cooper

Isophragma sp. 1

Kullervo sulcata Cooper

Leptellina pulchra Cooper

Lingulella alabamensis Cooper

L. lirata Cooper

L. pachyderma Cooper

Lingulella sp. 8

Nothorthis tarda Cooper

N. transversa Cooper

Obolus sp. 3

Obolus sp. 4

Orthambonites tenuicostatus Cooper

Pachyglossa dorsiconvexa Cooper

P. pachydermata Cooper

Parallelelasma pentagonum Cooper

Parastrophina bilobata Cooper

Paterula perfecta Cooper

Perimecocoelia semicostata Cooper

Phragmorthis buttsi Cooper

Ptychoglyptus virginianensis Willard

Rhysotreia corrugata Cooper

Scaphelasma septatum Cooper

Schizambon sp. 2

Schizotreia corrugata Cooper

S. subconica Cooper
S. willardi Cooper
Skenidioides convexus Cooper
Spinilingula intralamellata Cooper
Spondylotreta concentrica Cooper
Taphrorthis peculiaris Cooper
Titanambonites amplus (Raymond)
Torynelasma toryniferum Cooper

T. minor Cooper
Trematis elliptopora Cooper
T. ? spinosa Cooper
Triplexia carinata Cooper
Tropidothyris pentagona Cooper
Undiferina rugosa Cooper
Westonia superba Cooper
Xenambonites undosus Cooper

Correlation of Pratt Ferry formation.—The fauna of the Pratt Ferry formation is obviously closely related to that of the Arline formation and its correlatives. The position of the formation is most interesting because it really is a part of the Little Oak formation. Cambrian elements, such as *Lingulella*, and *Dictyonites* which is a member of the family Micromitridae, form another interesting feature of the fauna.

Red Knobs formation (B. N. Cooper and G. A. Cooper).—The Red Knobs formation is a thick succession of red to pink calcarenites and limy ferruginous sandstones up to 750 feet in thickness. The exposures from which the name is taken are near and along the Blount-Loudon County line, near Meadow, on the Meadow (T.V.A. 139-NW) Quadrangle. The lower part of the Red Knobs formation consists of red to pink marble—the Holston marble of Ulrich, Gordon, Rodgers, and others, which is well exposed in the old marble quarries just southeast of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle. The upper beds, which yield a characteristically dark-maroon, sandy regolith, are calcareous sandstones and ferruginous sandy calcarenites with partings of greenish-gray to buff shale. The marble beds contain *Multicostella*, *Atelelasma*, *Oxoplecia holstonensis*, and numerous bumastid trilobites.

Dinorthis venusta Cooper
Obolus ? grandis Cooper
O. ? virginienensis (Willard)
Oligorhynchia inexpectata Cooper
Oxoplecia gibbosa Cooper

O. holstonensis Willard
O. marmorata Cooper
Philhedra ferruginea Cooper
Skenidioides costatus Cooper
Valcourea sp. 3

Correlation of Red Knobs formation.—By position and faunal character this formation is correlated with the Benbolt. It occurs above the Arline. Its assemblage of species seems to be from the Arline.

Rich Valley formation (B. N. Cooper and G. A. Cooper).—This formation consists of black and chocolate-brown shales, containing abundant graptolites, brachiopods, and trilobites, which range in thickness from a few feet to 350 feet. The type section is immediately south of the Porterfield Quarry and Worthy Mine of the Mathieson Chemical Corp., about 7 miles east-southeast of Saltville on the Maccrady (T.V.A. 218-NW) Quadrangle, Smyth County, Va. The basal 40 feet of black shaly limestone which capped the limestone reef in Porterfield quarry (G. A. Cooper, 1940, pp. 17-20) constitutes the lower part of the Rich Valley formation. These beds have yielded some of the most remarkable fossils found in the Appalachian Valley, and most of the species listed below are from this part of the Rich Valley. At Quarry Village, south of Saltville on the Glade Spring (T.V.A. 212-SE) Quadrangle, the base of the Rich Valley

formation is black shale containing a profusion of Normanskill graptolites and the trilobites *Telephus bicornis*, *Robertia major*, *Porterfieldia caecigenus*, *Ampyx americanus*, *A. camurus*, and *Bevanopsis*. The beds herein defined as the Rich Valley shale are the lower and characteristic part of a unit widely identified by Butts, Decker, and others as Athens shale. The Rich Valley corresponds to the lower part of the Liberty Hall black-limestone-black-shale succession of central-western Virginia.

Bimuria immatura Cooper
Glyptambonites glyptus Cooper
Glyptomena parvula Cooper
Glyptorthis glypta Cooper
Kullervo ornata Cooper
K. parva Cooper
Laticrura pionodema Cooper
Leptellina pulchra Cooper
Obolus nitens Cooper
Orthambonites brachiophorus Cooper
O. divaricatus Cooper

O. parvicrassicosatus Cooper
Phragmorthis buttsi Cooper
Ptychopleurella mediocostata Cooper
P. rectangulata Cooper
Scaphorthis perplexa Cooper
Scaphorthis sp. 1
Schizambon sp. 1
Schizotreta shuleri (Willard)
Skenidioides transversus Cooper
Taphrorthis peculiaris Cooper

Rob Camp formation.—This formation was named by Miller and Brosge (1950) for heavy-bedded calcilitite with few fossils. The type locality is taken from exposures northeast of Rob Camp Church, Coleman Gap (T.V.A. 161-SW) Quadrangle in Virginia-Tennessee. The formation lies between the Poteet and Martin Creek limestones. No identifiable brachiopods have been found in this formation.

Rockdell formation.—This name was proposed by B. N. Cooper (1945b, p. 137) for a unit composed of the Peery and Ward Cove formations where they are inseparable. The formation consists of 58 to 420 feet of fine-grained, dark-gray limestone and gray calcarenite. The type section is near Elk Garden, Russell County. The formation is sandwiched between the Lincolnshire and the Benbolt formations. *Nidulites* is present in the dark limestones. See Ward Cove for brachiopods.

Rodman member of Nealmont formation.—According to the writer's observations, this member is really two facies rather than a true member. In central Pennsylvania it generally consists of about 30 feet of coarse calcarenite (similar to St. Luke facies) containing an abundance of fossils. It occurs at the top of the Nealmont formation and underlies the Salona formation. In places the top of the Nealmont is not calcarenite but consists of thin-bedded limestone, the bedding being marked by thin, dark shale partings. This lithology has also been placed in the Rodman. The list of species presented below is composed from a list presented by Field (1919, p. 424) together with the species identified by the writer.

Bilobia hemispherica Cooper
 **Christiania trentonensis* Ruedemann
Dalmanella n. sp.
 **Dinorthis pectinella* (Emmons)
Glyptorthis n. sp.

Leptaena charlottae Winchell and Schuchert = *Limbinurina insueta* Cooper

Leptaena n. sp.

**Orthis disparilis* Conrad

O. tricenaria Conrad = *Hesperorthis virginiensis* Cooper

Oxoplectia n. sp. = *O. pennsylvanica* Cooper

Parastrophia hemiplicata (Hall) = *Parastrophina hemiplicata* (Hall)

**Pionodema subaequata* (Conrad)

Plectambonites n. sp. = *Sowerbyella* n. sp.

Plectorthis pennsylvanica Cooper

Protozyga exigua (Hall)

Rafinesquina alternata (Conrad) = *R. trentonensis* (Conrad)

Sowerbyella sp. 2

Correlation of Rodman member.—The Rodman member is clearly related to the Oranda formation of Virginia, Maryland, and southern Pennsylvania. This is indicated by the presence of *Christiana*, *Bilobia*, *Hesperorthis*, *Leptaena*, *Rafinesquina*, and *Parastrophina*. Furthermore, the member lies under the Salona, in the same position occupied by the Oranda near Green Mount Church, north of Harrisonburg in Virginia.

Row Park formation.—This formation was named by Neuman (1951, p. 278) for a sequence consisting of two facies, one granular limestone and the other calcilutite, ranging in thickness from 30 to 680 feet and extending from Bessemer, W. Va., through Maryland into southern Pennsylvania. The type section is 0.2 mile northwest of Row Park, Md., about 7 miles west of Hagers-town. The granular limestones are best developed on the east side of the Massanutten syncline. In the western exposures the formation is composed mostly of calcilutite. The Row Park rests unconformably on the Beekmantown and is overlain by New Market limestone to which it is partially equivalent (see New Market).

Calcarenites in the lower part of the formation contain numerous brachiopods, but the calcilutites usually do not contain remains of these animals. Row Park brachiopods are:

"*Camerella*" *longirostris* Billings = *Onychoplectia obesa* Cooper

Camerella cf. *C. varians* Billings = *C. pennsylvanica* Cooper

Dactylogonia cf. *D. incrassata* (Hall)

Hesperorthis sp.

Mimella cf. *M. vulgaris* (Raymond)

Multicostella sp.

Ptychopleurella sp.

Rostricellula basalaris Cooper

R. plena (Hall)

Correlation of Row Park formation.—The Row Park formation is correlated with the Lenoir of Tennessee and Virginia and with the Crown Point-Valcour sequence of the Champlain Valley, N. Y. The presence of *Hesperorthis* and possibly *R. plena* are the links to the Valcour. Crown Point elements are numerous *Maclurites* in the lower part, *Onychoplectia*, and *Dactylogonia*.

St. Clair facies of Murfreesboro formation.—This name was proposed by Butts (1940b, p. 126) for the purely limestone facies of the Murfreesboro formation in Virginia, mainly northwest of the strike of Clinch Mountain. This

is now known not to be Murfreesboro, and the limestones have been placed in other formations.

St. Luke member (facies) of Edinburg formation.—This name was proposed by Cooper and Cooper (1946, p. 81) for dove-gray massive limestone beds and calcarenites occurring between the Oranda formation above and the *Nidulites-Lambeophyllum* beds of the Edinburg formation below. At the type locality, 1 mile S. 60° E. of St. Luke, Va., the member is 90 feet thick. It is often composed of calcarenite which contains *Cryptophragmus*.

Brachiopods taken from the St. Luke member are:

Doleroides sp.

Oligorhynchia bifurcata Cooper

Opikina sp.

Rostricellula sp.

Zygospira sp.

Correlation of St. Luke member.—The St. Luke is correlated by Cooper and Cooper (1946, p. 86) with the Witten formation. The presence of *Cryptophragmus*, *Zygospira*, and *Oligorhynchia* aid in making the correlation.

St. Paul group.—This term was proposed by Neuman (1951, p. 278) as a substitute for the outmoded and erroneous name "Stones River" as applied throughout West Virginia, Maryland, and southern Pennsylvania. The type section is located near St. Paul's Church, Md., at the intersection of U. S. Highway 40 and Maryland Highway 57, 9 miles west of the center of Hagerstown. The group consists of the Row Park formation at the base and the New Market formation at the top.

Salona formation.—This formation extends from Pennsylvania into northern Virginia. It consists of black or dark argillaceous limestone and dark calcareous shale usually with numerous fossils. In Virginia it overlies the Oranda formation and is more shaly than is usual in Pennsylvania. In the latter State the Salona formation overlies the Rodman member of the Nealmont formation. In Virginia much of the Salona fauna appears to have been inherited from the underlying Oranda formation. A similar condition is true in Pennsylvania because some of the Rodman elements pass into the Salona. The trilobite *Brongniartella* is the most significant marker of the Salona formation.

Brachiopods are numerous. For a faunal list of the Salona fauna in Virginia, see Martinsburg. Additional brachiopods from the Salona (Kay, 1944, p. 112) of Pennsylvania are:

Colaptomena leptostrophoidea Cooper

Conotreta rusti Walcott

Dalmanella sp.

Leptaena sp. aff. *L. rhomboidalis* (Wilckens) = *L. ordovicica* Cooper

Leptelloidea pisum (Ruedemann) = *Bilobia hemispherica* Cooper

Oxoplectia sp. cf. *simulatrix* (Bassler) = *O. pennsylvanica* Cooper

Parastrophina hemiplicata (Hall)

Porambonites sp. = *Porambonites* sp. 4

Salonia magnaplicata Cooper and Whitcomb

Sowerbyella cava Cooper

Sowerbyella sp.

Strophomena sp.

Rafinesquina sp.

Sevier formation (=facies).—This name is applied to a thick series of sandy shales and fine-grained sandstones with intercalated beds of calcarenite, bryozoan "reefs," and thin lenses of sandy limestone. The color of the rock is blue-gray when fresh but weathers to a dull yellow. The formation is very thick and is best developed in the belts south of Knoxville and along the Great Smoky Mountain Front into northern Georgia. In the vicinity of Friendsville the Sevier formation overlies the Red Knobs formation and contains fossils that suggest a Benbolt age. In the belt along the Great Smoky Mountain Front, on the other hand, the Sevier formation is very extensive. In northern Georgia, near the village of Cisco, Sevier-type lithology succeeds Tellico sandstone and extends to the base of the Bays red beds. The Sevier appears to be a facies rather than a definite formation.

In Guthrie Gap, southeast of Whitehorn, Bulls Gap (T.V.A. 171-SE) Quadrangle, fossils have been taken from Sevier-type rock at the church in the gap which indicate a correlation of that part of the Sevier with the Witten formation. In the vicinity of Fourmile Church, Tallassee (T.V.A. 139-SE) Quadrangle, fossils taken just under the Bays red beds contain *Pionodema* and are thus likewise indicative of a Witten age. The evidence indicates that the Sevier ranges from Benbolt to as high as Witten in the standard section.

The subjoined list indicates the species that have been identified from the Sevier formation, and in the right-hand column the probable level from which each was taken.

| | |
|--|----------------------------|
| <i>Chaulistomella brevis</i> (Willard) | Benbolt-Wardell equivalent |
| <i>Cyclospira sulcata</i> Cooper | Wardell " |
| <i>Cyrtonotella magna</i> Cooper | Benbolt " |
| <i>Dactylogonia</i> sp. 4 | " " |
| <i>Dinorthis tenuis</i> Cooper | " " |
| <i>D. transversa</i> Willard | " " |
| <i>Glyptorthis subcarinata</i> Cooper | " " |
| <i>G. uniformis</i> Cooper | " " |
| <i>Hesperorthis dubia</i> Cooper | " " |
| <i>Multicostella robusta</i> Cooper | " " |
| <i>Oligorhynchia angulata</i> Cooper | " " |
| <i>O. bifurcata</i> Cooper | Witten " |
| <i>Oxoplectra multicostellata</i> Cooper | Benbolt " |
| <i>O. planiventra</i> Cooper | " " |
| <i>Paurorthis ponderosa</i> Cooper | " " |
| <i>Rhipidomena filicostellata</i> Cooper | " " |
| <i>Sowerbyites delicatus</i> Cooper | " " |
| <i>Sphenotreta cuneata</i> Cooper | Witten " |
| <i>Teratelasma neumani</i> Cooper | Benbolt " |
| <i>Zygospira mediocostellata</i> Cooper | Witten " |
| <i>Zygospira</i> sp. | " " |

The lower part of the Sevier just above the Meadow marble contains many species suggestive of Hogskin affinities. This is taken as a facies development in the lower yellow shales of the Sevier which are similar to the Hogskin shale.

Shannondale member of Benbolt formation.—This is another name of

Cooper and Prouty (1943, p. 868) for argillaceous, dark-gray, nodular-weathering limestone, often with a dark, bluish-gray coarse-grained limestone at the base. These coarse-grained rocks are local in their development. The member is variable in thickness but attains 100 feet. It is named from exposures along the northwest base of East River Mountain south of Shannondale on U. S. Highway 19. Cooper and Prouty (1943, p. 870) report the following brachiopods:

**Camerella quadriplicata* (Willard)

**Camarella* cf. *C. varians* Billings

Campylorthis sp. = *Chaulistomella* sp.

Dinorthis quadriplicata Willard = *D. transversa* Willard

**Glyptorthis bellarugosa* (Conrad)

Mimella melonica (Willard) = *M. globosa* (Willard)

**Öpikina* "minnesotensis" (N. H. Winchell)

**Plectorthis* cf. *P. exfoliata* Raymond

Ptychoglyptus sp. (probably *Bellimurina* sp. True *Ptychoglyptus* not seen this high by the writer)

*"*Rafinesquina*" cf. *R. deltoidea* (Conrad) = *Öpikina*

*"*Rafinesquina*" sp. = *Öpikina*

Sowerbyella sp.

Strophomena tennesseensis Willard = *Rhipidomena tennesseensis* (Willard)

*"*Zygospira*" cf. *Z. acutirostris* (Hall) = *Sphenotreta cuneata* Cooper ?

Shippensburg formation.—This formation with type section in the railroad cut $2\frac{1}{2}$ miles southwest of Marion, Pa., was defined by Craig (1949, p. 717). In the eastern belts of south-central Pennsylvania the formation attains its greatest thickness of 416 feet. Here it is divided into two members: Pinesburg and Fannettsburg. In the western belts the formation is thinner, but there a third member, the Doyleburg, appears above the Fannettsburg. The Shippensburg formation consists of five lithologic types: Dark-gray, fine-grained cobbly limestone; fine-grained, dark-gray and evenly bedded limestone; medium to coarse calcarenite; interbedded dark-gray, medium-grained limestone; and calcilitite pellet conglomerate and dove calcilitite. The brachiopod content of the formation is discussed under the individual members.

Snyder member of Benner formation.—Described by Kay (1944, p. 15) for a calcilitite attaining a thickness of 110 feet in central Pennsylvania; this member forms the lower part of the Benner formation. Conglomerates with white limestone pebbles are diagnostic of the member, which has not yet yielded brachiopods.

Speers Ferry formation.—This name was used by Ulrich (1939, p. 106) in a correlation chart, but no description was ever published to validate it. On that chart the formation appears in a column headed Clinton and Pearisburg troughs. It is placed between the Ottosee below and the Pierce formation above. According to present understanding of Appalachian stratigraphy, this position is impossible. The Speers Ferry may have been designed for the beds now called Wardell.

Stones River group.—This is a group term (see C. W. Wilson, 1949) which, after some refinements, was made to contain four formations in ascend-

ing order: Murfreesboro, Pierce, Ridley, and Lebanon. Although the Carters formation which succeeded the Lebanon was originally included in the Stones River group by Safford, it was thrown out by Ulrich and Bassler because it was correlated with the Lowville and could not be included in their Chazyan Stones River group. Views on this subject have lately changed, and it has been shown that the rocks of the Stones River group of the Central Basin of Tennessee were deposited after those of the Chazy (G. A. Cooper in Schuchert, 1943, p. 474; B. N. Cooper, 1945a, pp. 262-275). In 1949 C. W. Wilson (p. 24) returned the Carters (originally Carters Creek) formation to its old position at the top of the Stones River group.

The term "Stones River group" is appropriate to the Central Basin of Tennessee and possibly parts of Alabama but not to most parts of the Appalachians to which it has already been applied. For years this term has been used for the lower or "Chazyan" part (Lenoir through Lincolnshire) of the Appalachian section from Pennsylvania to Alabama. It was also just as inappropriately applied to parts of the Minnesota section. Identification of the Carters formation of the Central Basin as Lowville, because of the presence of *Tetradium cellulosum*, was the chief factor in declaring the subjacent beds, Lebanon through Murfreesboro, as Chazyan in age. A similar error was made in the Appalachians in identifying all the formations below the *Cryptophragmus* and *Tetradium cellulosum*-bearing "Lowville" as Chazyan in age. This threw the lower formations of the Appalachians into correlation with the Stones River formations. Thus, because of the common presence of *Maclurites* and the position in relation to "Mosheim" rocks, Lenoir and Ridley were correlated, and from these false premises many other errors were brought about which are detailed by B. N. Cooper (1945a). (See Chickamauga.)

Examination of the fossils of the Stones River formations of the Central Basin of Tennessee shows that the affinities of this group are with the old Black River-Trenton (Wilderness) assemblage of formations rather than with the Chazy (Marmor). It is evident, therefore, that the Stones River as a group term should be dropped from the Appalachians.

Stover member of Benner formation.—Mostly a dense, heavy-ledged limestone with *Camarocladia* markings numerous. The formation attains a thickness of about 90 feet but varies to a low of slightly less than 30 feet. The formation was described by Kay (1944, p. 17) and its type section is at Union Furnace in central Pennsylvania. *Cryptophragmus* occurs with a few other fossils. Brachiopods are:

Ancistrorhyncha sp.

Glyptorthis sp.

**Öpikina* sp. cf. *Ö. wagneri* (Okulitch)

**Strophomena* sp. aff. *S. filitexta* (Hall)

Strophomena sp.

Zygospira sp. cf. *Z. recurvirostris* (Hall)

Correlation of the Stover member of the Benner formation.—*Cryptophragmus*, *Camarocladia*, and *Zygospira* indicate correlation with part of the Witten formation of Cooper and Prouty.

Strasburg formation.—This is another undefined name of Ulrich's (1939, p.

106) which appears on a chart. This is in the Clinton and Pearisburg troughs between the Lenoir below and the Holston above. It is thus in the position of the Lincolnshire formation.

Surgener formation.—This name is proposed by B. N. Cooper and G. A. Cooper for chalky-weathering dark limestone, cherty dark limestone, gray to buff mudstone, and maroon mudstone that occupy an interval from about Elway through Peery. The name is used in southwestern Virginia and adjacent parts of East Tennessee. The name is taken from a small cemetery $\frac{1}{2}$ mile due east of the section along Yellow Creek, Rose Hill (T.V.A. 161-NE) Quadrangle, but the type section is just east of the Hagan Switchback on the L. and N. RR., $4\frac{1}{2}$ miles due north of Surgener Cemetery, Rose Hill (T.V.A. 161-NE) Quadrangle. The Surgener is also well displayed at the south (blind) end of the Hagan Switchback. Good sections occur at Hagan, Dryden, and Yellow Branch, Va., and at Rose Hill and near Andersonville Dock, Tenn. At Hagan the sequence embraces the Poteet, Rob Camp, and Martin Creek formations of Miller and Brosge (1950). These names may be consulted for lists. Thin marine fingers in the maroon and buff mudstones near Rose Hill, Tenn., produced *Oligorhynchia bifurcata* Cooper and *Plectocamara*. Other brachiopods taken from the Surgener formation are:

Ancistrorhynchia crassa Cooper

Rhipidomena tenuitesta (Willard)

Tellico formation.—This name is used for a predominantly clastic formation occurring in the southeastern belts of the Southern Appalachians in East Tennessee and northern Georgia. Neuman (1956) has amplified this name to include shales equivalent to Upper Athens, the Tellico sandstone, and lower part of the Sevier. In the belt along the west front of the Great Smoky Mountains the formation is several thousand feet thick and consists of some thick calcareous sandstones and sandy shales. These weather to a red or brown soil by leaching of the lime, and produce lines of knobs. Rocks identified as this formation are also developed in the belts north to Knoxville, but uncertainty exists as to their identification with the Tellico of the type belt along the Great Smoky Front. In these belts considerable hematite and marble containing numerous fossils occur in the formation.

In its type belt the Tellico overlies shales (Blockhouse) with graptolites that are only partially equivalent to the Athens formation; the Tellico is overlain by shales and sandstones (Sevier) of uncertain correlation. In the belts passing through Friendsville and Knoxville the sands and calcarenites mistaken for Tellico overlie "Holston" marble (=Red Knobs) and are overlain by the Sevier formation. In this belt "Tellico" fossils are clearly related to those of the Arline formation and possibly fossils occurring as high as Benbolt. It is probable, therefore, that the type Tellico is actually older than that of the belts north of Athens. The entire interval of shale and sandstones from the Knox to the base of the Sevier formation is equivalent on the basis of fossils to the interval from the

top of the Knox through the "Tellico" = Red Knobs of the belts south of Knoxville.

Bimuria superba Ulrich and Cooper

Dinorthis tenuis Cooper

Leptellina tennesseensis Ulrich and Cooper

Orthambonites neumani Cooper

Paworththis catawbensis (Butts)

P. fasciculata Cooper

Sowerbyites lamellosus Cooper

Thompson Valley formation.—Prouty (1946, p. 1152) proposed this name for the coarse calcarenite in the lower part of the Ward Cove formation in parts of Virginia and East Tennessee. It is the coarse-grained limestone mentioned by B. N. Cooper (1944, p. 42) in the Burkes Garden Quadrangle report. Prouty thus restricted the Ward Cove formation to the finer-grained limestone in which *Nidulites* is abundant. The Thompson Valley formation is best developed in the median belts of the Appalachian Valley and occurs locally in the northwestern belts. The formation thus overlies Lincolnshire (or Hogskin member) and underlies the restricted Ward Cove. The name does not appear on the chart. The following brachiopods have been reported:

Dactylogonia magnifica Cooper

Dinorthis atavoides Willard

Mimella sp.

Oligorhynchia subplana Cooper

Oxoplectra holstonensis Willard

Schizambon sp.

Toqua formation (R. B. Neuman, 1956).—This is a name for a sandstone facies of the Blockhouse formation which replaces the dark shales to the southwest along the base of the Great Smoky Mountains in East Tennessee. The Tellico sandstone in the section at Cisco, Ga., may be in part Toqua sandstone.

Tumbez formation.—This formation was defined by B. N. Cooper (1945b, p. 133) with type section 1 mile south of Tumbez, Russell County, Va. It consists of a basal boulder conglomerate succeeded by dolomite, mudrock, and calcarenite containing *Rostricellula basalaris* and *Mimella nuclea*. It underlies Elway and overlies the Mascot dolomite (Lower Ordovician) unconformably. The formation is equivalent to the *Rostricellula* beds of the Lenoir and is also well displayed under the *Maclurites* beds in a small quarry 3.4 miles southwest of Marion, Va.

Dactylogonia alternata Cooper

Mimella nuclea (Butts)

Rostricellula basalaris Cooper

Valentine member of Curtin formation (Kay, 1944, p. 21).—Pure quarry rock, dove calcilutite in central Pennsylvania. The only brachiopod so far reported is a large *Lingula* sp.

Valley View member of Curtin formation (Kay, 1944, p. 20).—This is the lower member of the Curtin formation of central Pennsylvania from which no brachiopods have been reported or seen by the writer in sections studied by him.

Vestal marble.—This name is applied to a marble 150 to 200 feet thick near the base of Sevier formation on the south side of Knoxville. It has about the same position as the Meadow marble.

Walker Mountain sandstone member of Moccasin formation.—This name was proposed by Butts and Edmundson (1943, p. 1678) for the upper of the two sandstones in the Moccasin formation in the southwestern end of Walker Mountain. No type section is designated, but the best display of the member is said to be along Keywood Branch Road about $\frac{1}{2}$ mile north of Seven Springs and along Virginia Highway 91, about a mile northwest of McCall Gap, Washington County. No fossils have been named from the formation. It is composed of thick-bedded, gray, quartzose rock 8 to 12 feet thick. The name is not placed on the chart because it has little significance, but if it were placed there it would appear in the Marion and Porterfield Quarry columns.

Ward Cove formation.—This formation was made by Cooper and Prouty (1943, p. 863) for a limestone on the southeast side of Clinch Mountain which overlies the Lincolnshire formation (Thompson Valley, according to Prouty) and underlies the Peery. The type section is along State Highway 91 at the northwest base of Clinch Mountain near Ward Cove, Tazewell County, Va. The lower part of the formation consists of an average of 60 feet of shell breccia and calcarenite (Thompson Valley of Prouty); the upper part is composed of 75 to 150 feet of cherty medium- to fine-grained limestone, quite argillaceous in Burkes Garden and Thompson Valley. Prouty (1946, p. 1152) later named the shell breccia and calcarenite portion "Thompson Valley formation." The Ward Cove formation is characterized by the fossil *Nidulites pyriformis*. Brachiopods are fairly common but are difficult to obtain in good condition.

The formation has been recognized in several belts in East Tennessee where it deviates from the lithology of the type area. Biohermal masses of bryozoans occur in the belt passing through Elza, Tenn.

Camerella unicosta Cooper

Dactylogonia magnifica Cooper

Fascifera sp. 1

Glyptomena sp. 1

Leptellina sp.

Lingula cf. *L. nympha* Billings = *Ectenoglossa nymphotoidea* Cooper

Lingula sp.

Neostrophia sp. 1

Oligorhynchia angulata Cooper

O. bifurcata Cooper

O. subplana Cooper

Opikina transversa Cooper

Oxoplectia gibbosa Cooper

O. holstonensis Willard

Paurorthis fascifera Cooper

Plectocamara aseptata Cooper

Plectorthis transversa Cooper

Protozyga microscopica Cooper

Schizambon cuneatum Willard

Skenidioides mediocostatus Cooper

Sowerbyella aequistriata (Willard)

S. delicatula (Butts) = *Leptellina delicatula* (Butts)

S. negritus (Willard)

S. parva Cooper

Strophomena tenuitesta Willard = *Rhipidomena tenuitesta* (Willard)

**Zygospira* sp.

Correlation of Ward Cove formation.—This formation in the western belts of Virginia takes the place of the Arline formation and has species related to the Arline.

Wardell formation.—This formation was proposed by Cooper and Prouty (1943, p. 873) with type section near the settlement of Wardell near the Tazewell-Russell County line. The formation has a thickness of 200 feet or more in median and southeastern belts of the Appalachians in Virginia and Tennessee. The lithology is variable and consists of limestones, calcarenites like the Effna, dove calcilutites, and shales. Where the Gratton is not present the formation is difficult to separate from the Benbolt, as at Rye Cove, and the two combined are known as Dryden formation. The fauna, however, is very prolific and abounds in brachiopods. The list includes identifications by Cooper and Prouty with additions by the writer:

Ancistrohynchia costata Ulrich and Cooper

A. crassa Cooper

Bellinurina sp. 2

Camerella plicata Schuchert and Cooper

Camarotoechia ? *plena* (Hall) = *Rostricellula rostrata* Ulrich and Cooper

Chaulistomella inaequistriata Cooper

C. rectangulata Cooper

Dinorthis transversoides Cooper

Doleroides regularis Cooper

Fascifera stonensis (Safford)

Glyptorthis irregularis Cooper

Glyptorthis sp.

Hesperorthis cf. *H. tricenaria* (Conrad) = *H. australis* Cooper

**Mimella globosa* (Willard)

M. wardellana Cooper

Murinella muralis Cooper

Oligorhynchia elongata Cooper

Oligorhynchia sp.

Öpikina speciosa Cooper

Ö. subplanodorsata Cooper

**Pionodema subaequata* (Conrad)

P. subaequata circularis (Winchell) = *Fascifera subcarinata* Ulrich and Cooper

Plectocamara erecta Cooper

Protozyga rotunda Cooper

Rostricellula ovata Cooper

Rostricellula sp. 2

Schizambon lineatum Cooper

S. macrothyris Cooper

Sowerbyella aequistriata (Willard)

S. socialis Cooper

S. socialis crassa Cooper

**Strophomena* cf. *S. emaciata* Winchell and Schuchert

S. incurvata ? (Shepard) = *S. medialis* Butts

S. inspeciosa Willard

Valcoura cf. *V. deflecta* (Conrad) = *Chaulistomella inaequistriata* Cooper

Correlation of Wardell formation.—The Wardell formation appears to be the equivalent of the Ridley limestone in the Appalachian Valley. This equivalence is shown in the common presence in the two formations of *Fascifera stonensis*, *Ancistrohyncha costata*, and *Öpikina speciosa*. The Wardell and Ridley also see establishment of the genus *Strophomena* which appeared in Murfreesboro. The Wardell is the level at which *Doleroides* appears in abundance and virtually displaces *Mimella*, which is commonest below. The Wardell thus contains a more modern fauna than that of the Benbolt below, and the New York-Canada elements become conspicuous. Most of the genera of the Benbolt suite fail to pass over into the Wardell.

Wassum formation (B. N. Cooper and G. A. Cooper).—The Wassum formation consists of *Solenopora*- and *Stromatocerium*-bearing calcarenites and buff crumbly shales with *Receptaculites*, which underlie the red sandy mudstones of the Bays formation and which succeed the black petroliferous limestones of the Chatham Hill formation. The type locality is 4 miles northwest of Marion, Marion (T.V.A. 218-SE) Quadrangle, Smyth County, Va. In the type locality the formation is about 125 feet thick and composed principally of variegated marble or calcarenite. On Walker Mountain south of Chatham Hill, Smyth County, Va., the Wassum formation is fully exposed with a total thickness of about 150 feet. The fossils and position of the Wassum formation place it opposite the upper part of the Wardell and part of the Dryden formations of middle and western belts of the Appalachian Valley. The formation extends northeastward in one persistent belt of outcrop to Sinking Creek Valley, Giles County, Va., where it carries *Favistella halli* and *Stromatocerium* in abundance.

Whistle Creek formation.—This name is applied by Cooper and Cooper (1946, p. 74) to dark, cherty limestones underlying the Lincolnshire or its equivalent along U. S. Highway 60 and Whistle Creek, northwest of Lexington, Va. The full extent of this formation is not yet known. Fossils are abundant in many places and often weather out of the limestone by solution. The known brachiopods are:

Ateleasma perfectum Cooper ?
Camerella globularis Cooper
Dactylogonia sp. 7
Dinorthis holdeni (Willard)
Hesperorthis longirostris Cooper
Macrocoelia elegantula Cooper
Mimella intermedia Cooper
M. virginensis Cooper

Multicostella quadrata Cooper
Murinella parva Cooper
Öpikina sp. 5
Oxoplectra costellata Cooper
Protozyga nasuta Cooper
Rhipidomena
Valcourea austrina Cooper

Correlation of Whistle Creek formation.—The Whistle Creek formation is related to the Elway formation by virtue of the common presence of *Dinorthis holdeni*.

Whitesburg formation.—This formation was so ambiguously defined that the name is no longer of any use outside its type locality. At the type section $2\frac{1}{2}$ miles southeast of Whitesburg, on Bulls Gap (T.V.A. 171-SE) Quadrangle, siliceous limestones about 10 feet thick rest on the *Maclurites* beds of the Lenoir formation. The siliceous limestones contain *Christiania* and other fossils char-

acteristic of the Botetourt or Fetzter formations. These siliceous limestones are overlain by about 600 feet of slabby, carbonaceous limestone and shaly limestone similar lithologically to the Liberty Hall facies of Virginia.

Only at the type section is the Whitesburg of such great thickness. Wherever it was recognized elsewhere by Ulrich and Butts it is some 50 feet or less thick and is a siliceous, brown-weathering, resistant limestone underlying the "Athens" but overlying "Lenoir" or "Holston." The Lenoir and Holston in these instances are the Lincolnshire and Murat formations. In Catawba Valley this remnantal Whitesburg is well developed and interfingers with Effna limestone. Cooper and Cooper (1946, p. 80) named this resistant thin bed the Botetourt member (now formation) of the Edinburg formation.

In Alabama the Pratt Ferry limestone of Cooper and Cooper was also referred by Butts and Ulrich to the Whitesburg formation, but it actually occupies a position somewhere within the Little Oak. Inasmuch as the several hundred feet of the Whitesburg, like the Virginia "Athens," are conspicuous in the Bulls Gap area, the name is used locally.

Dark, thin-bedded limestone overlying the Effna formation at Porterfield Quarry near Saltville, Va., carries a holdover fauna of the Effna and is here assigned to the Rich Valley formation. Brachiopods of the Whitesburg are:

Anisopleurella inaequistriata Cooper

Camerella sp. 4

Conotreta magna Cooper

C. multisinuata Cooper

Ectenoglossa nymphoidea Cooper

Elliptoglossa ovalis (Bassler)

Leptellina bella Cooper

Lingulella lirata Cooper

L. spicata Cooper

Multicostella bursa (Raymond)

Paterula perfecta Cooper

Trematis ? *parva* Cooper

Trematis sp. 1, 2

Triplexia sp. 1

Westonia sp. 1

Witten formation.—This name was proposed by Cooper and Prouty (1943, p. 877) for limestones overlying the red Bowen formation in Virginia and East Tennessee. The formation is especially characterized by *Cryptophragmus* which is often found in calcarenites. *Camarocladia*-bearing limestone is also a prominent feature of the formation. In places tongues of mudrock appear. The formation is widespread in southern Virginia and many of the belts of East Tennessee. The red Bowen formation usually separates the Wardell and Witten formations, but where it is absent faunal differences may be relied on. The Witten formation contains numerous brachiopods, but they are often not well preserved or are difficult to extract from the rock. Brachiopods are as follows:

Doleroides sp.

Hesperorthis aff. *H. tricenaria* (Conrad)

Oligorhynchia bifurcata Cooper

Pionodema minuscula Willard

Rostricellula compressa Cooper

R. subtransversa Cooper

Sowerbyella cf. *S. lebanonensis* Bassler

Zygospira "recurvirostris" (Hall)

Correlation of Witten formation.—This formation is correlated with the Lebanon of the Central Basin of Tennessee because of the common presence of *Pionodema minuscula* Willard and *Rostricellula compressa* Cooper. It also records the earliest occurrence of *Zygospira* in the Appalachians.

Woodway formation.—This formation name was proposed by Miller and Brosge (1950) for cryptocrystalline, tan and gray limestone with interbeds and zones of medium-crystalline limestone. A prominent zone of *Stromatocentrum rugosum* occurs at the base. The formation is named from exposures on the slope of Wallen Ridge east of Woodway, Stickleyville (T.V.A. 179-NW) Quadrangle, Va. Brachiopods occurring in this formation are:

Ancistrorhyncha costata Ulrich and Cooper
Doleroides cf. *D. gibbosus* (Billings)
Hesperorthis aff. *H. tricenaria* (Conrad) = *H. australis* Cooper
Pionodema minuscula Willard
Protozyga sp.
Rostricellula sp.
Strophomena sp.
Zygospira recurvirostris (Hall)

Besides the *Stromatocentrum* this formation contains *Cryptophragmus*. The former is more commonly a Wardell species, and the latter belongs to the Witten formation as a rule. It is evident, therefore, that Miller and Brosge's Woodway formation includes parts of the Wardell (=Upper Dryden) and Witten formations. Of the brachiopods the *Ancistrorhyncha* and *Hesperorthis australis* are Wardell fossils. *Pionodema* and *Zygospira* are Witten guide fossils.

Yellow Branch member of Poteet formation (B. N. Cooper and G. A. Cooper).—This thin but easily recognizable unit corresponds to the "nine-foot limestone bed" of Butts (1940b, p. 122, pl. 24, C) in the much-discussed section along Yellow Branch (so called locally, but Yellow Creek on the Rose Hill Quadrangle), $5\frac{1}{4}$ miles south of Hagan and 2 miles north of the Tennessee line, Rose Hill (T.V.A. 161-NE) Quadrangle. The formation is gray, thick-bedded calcarenite about 8 or 9 feet thick, and carries fossils that make it of special interest. The brachiopod genera *Mimella*, *Glyptorthis*, *Camerella*, and *Murina* are suggestive of the upper Ridley, although Butts classed the beds in the Murfreesboro limestone. The Yellow Branch member is also fully exposed along the L. and N. RR. switchback south of Hagan, Lee County, Va.

Camerella edmundsoni Cooper
Dactylogonia sp. 8
Glyptorthis senecta Cooper

Mimella globularis Cooper
Murina muralis Cooper

5. THE CENTRAL BASIN OF TENNESSEE, WELLS CREEK BASIN AND HIGH BRIDGE, KENTUCKY

The early Middle Ordovician sequences of the Central Basin of Tennessee and High Bridge, Kentucky, are composed of limestones closely related faunally to the upper part of Southern Appalachians sequence. A complete section from the Lower Ordovician to the Trenton is not exposed in either area because the bottom portion, probably several hundred feet thick, is under cover.

CENTRAL BASIN OF TENNESSEE

The formations of interest here in the Central Basin are the Stones River group and the Hermitage formation. The Stones River group, as redefined by C. W. Wilson (1949, pp. 24-75) consists of five formations from the bottom: Murfreesboro, Pierce, Ridley, Lebanon, and Carters limestones.

Murfreesboro formation.—This formation consists of about 70 feet of dark-gray, cherty, moderately heavy-bedded limestone on the outcrop. Collins and Bentall (1945) report approximately 400 feet of this formation in wells drilled in central Tennessee. Fossils are common but are usually silicified and enclosed by chert. The fauna abounds in gastropods, but a few brachiopods have been reported by Bassler, as follows: *Dinorthis deflecta* (Conrad), *Orthis tricenaria* Conrad, *Pianodema* (sic) *subaequata* (Conrad), and *Strophomena filitexta* Hall. In four visits to the Central Basin the writer has been unable to verify this list except for the presence of an abundant strophomenoid. No specimens from the Murfreesboro formation in the National Museum or in the Schuchert Collection at Yale University corroborate the first three species. Murfreesboro brachiopods are:

Camerella nuda Cooper
Murinella sp. 1
Plectorthis sp. 2

Protozyga uniplicata Cooper
Strophomena planobesa Cooper

Correlation of Murfreesboro formation.—The Murfreesboro formation is generally correlated on fossils other than brachiopods. It contains a scaphopod, *Polylophia billingsi* (Safford) in abundance. B. N. Cooper (1944, pp. 69-71) correlates the Murfreesboro formation with the Peery formation of Tazewell County. As explained under the Chickamauga limestone, the Murfreesboro formation is present in northwestern Georgia but its correlation elsewhere is not clear. A representative of it may occur in Missouri in the Rock Levee formation. The Blackford has nothing to do with Murfreesboro.

Pierce formation.—This formation consists of 27 feet of thin-bedded limestone separated by shaly partings. Fossils, particularly bryozoans, are abundant. The following brachiopods are known:

Ancistrorhyncha costata Ulrich and Cooper
Bellimurina concentrica Cooper
Doleroides regularis Cooper
Doleroides sp. 1
Fascifera stonensis (Safford)
Glyptorthis irregularis Cooper
Minella biconvexa Cooper

Opikina ? planulata Cooper
Philhedra minor Cooper
Protozyga sp.
Rostricellula rostrata Ulrich and Cooper
R. variabilis Cooper
Strophomena planobesa Cooper

Pionodema subaequata has also been reported but was not seen by the writer. The report is probably erroneous. A small *Mimella* may have been confused with the punctate genus, an error that is frequently made.

Correlation of Pierce formation.—The Pierce formation is closely related to the Ridley formation which overlies it, and the two may be only facies of each other. In Sequatchie Valley, Tenn., Pierce has been identified, but there, too, it

is probably a shaly part of the Ridley. This seems to be the case in northwestern Georgia where the Ridley is partially a shaly facies. *Fascifera* appears in all the shaly facies, and *F. stonensis* is identified in the Wardell formation which is correlated with the Ridley.

Ridley formation.—This consists of about 93 to 115 feet of dark cherty limestone containing an abundance of fossils, often beautifully silicified. In places the coral *Tetradium* is common, and *Öpikina* occurs in countless numbers at the top of the formation. Brachiopods identified are:

- Ancistrohyncha costata* Ulrich and Cooper
- Camerella varians* = *C. plicata* (Schuchert and Cooper)
- C. pulchra* Cooper
- Chaulistomella superlata* Cooper (in Georgia)
- Dinorthis deflecta* = *Chaulistomella ridleyensis* Cooper
- Doleroides crassus* Cooper (Georgia)
- D. extensus* Cooper (Georgia)
- Fascifera subcarinata* Ulrich and Cooper
- Glyptorthis multicostellata* Cooper (Georgia)
- Hebertella bellarugosa* = *Glyptorthis assimilis* Cooper
- Mimella biconvexa* Cooper
- M. globosa* (Willard) (Georgia)
- Öpikina maja* Cooper
- Ö. quadrata* Cooper
- Ö. speciosa* Cooper
- Orthis tricenaria* Conrad = *Hesperorthis australis* Cooper
- Petrocrania* sp. 1 (Georgia)
- Pianodema subaequata* (probably a misidentification)
- P. stonensis* (Safford) = *Fascifera stonensis* (Safford)
- Protorhyncha rideleyana* (Safford) = *Ancistrohyncha costata* Ulrich and Cooper
- Protozyga rotunda* Cooper
- Rafinesquina incrassata* (Hall) = ?
- Rostricellula rostrata* Ulrich and Cooper
- R. variabilis* Cooper
- Strophomena filitexta* = *S. basilica* Cooper
- S. planobesa* Cooper (in Sequatchie Valley)

Correlation of Ridley formation.—The correlation of the Ridley formation is with the Wardell of the Southern Appalachians. This is based on the common presence of *Fascifera*, *Hesperorthis australis*, *Öpikina speciosa*, and *Ancistrohyncha costata*. The Ridley of the Central Basin of Tennessee with its scattered and light-colored chert cannot be correlated lithologically with the "Lenoir" of the Appalachians which has black chert. Furthermore, the "Lenoir" of the Appalachians includes a variety of formations, none of which is faunally like the Ridley. Certainly the Lenoir as now restricted has no species in common with the Ridley. Correlation of the Ridley of northwestern Georgia is discussed under the Chickamauga.

Lebanon formation.—This formation consists of approximately 100 feet of thin-bedded limestone separated by thin beds of shale often containing exquisite fossils. *Camarocladia* markings are frequent and conspicuous. A thick bed of calcarenite (about 3 feet thick) containing abundant *Cryptophragmus* occurs

near the middle of the formation in the vicinity of Readyville. The following brachiopods have been identified:

- Acanthocrania* sp. 1
- Ancistrorhyncha australis* (Foerste)
- Bellimurina parvuplicata* Cooper
- Camarotoechia orientalis* = *Rostricellula compressa* Cooper
- Didymelasma longicrurum* Cooper
- Dinorthis deflecta* = *Chaulistomella lebanonensis* Cooper
- Doleroides tennesseensis* Cooper
- Hallina saffordi* (Hall)
- Hebertella bellarugosa* = *Glypthorthis irregularis* Cooper
- **H. borealis* (Billings) = probably a misidentification
- Öpikina eximia* Cooper
- Ö. septata* Salmon
- Orthis tricenaria* = *Hesperorthis quadrata* Cooper
- Pionodema subaequata* = *Pionodema minuscula* Willard
- Plectorthis lebanonensis* Cooper
- Protozyga rotunda* Cooper
- Rostricellula compressa* Cooper
- R. truncata* Cooper
- Skenidioides halli* (Hall and Clarke)
- Sowerbyella lebanonensis* Bassler
- Strophomena filitexta* = *S. grandimusculosa* Cooper
- Triplesia subcarinata* Cooper
- Zygospira circularis* Cooper
- Z. elongata* Cooper
- Z. lebanonensis* Cooper
- Z. saffordi* Winchell and Schuchert = *Hallina saffordi* Winchell and Schuchert

Correlation of Lebanon formation.—The Lebanon limestone is correlated with the Witten limestone of the Appalachian Valley. These two formations have *Pionodema minuscula*, *Doleroides*, *Rostricellula compressa*, and abundant *Zgyospira* in common. The presence of *Triplesia subcarinata*, which is quite similar to *T. extans*, is a link to the Rockland of New York and Ontario. In addition to the brachiopods the Lebanon and Witten share *Cryptophragmus* and *Camarocladia*.

Carters formation (originally Carters Creek).—C. W. Wilson (1949, pp. 50, 58) divides this formation into lower and upper members and drops the name Tyrone, from the Central Basin of Tennessee, hitherto used for the upper member. The lower member is generally heavy-bedded and abounds in coral-line animals: *Foerstephyllum*, *Stromatocerium*, *Solenopora*, *Dystactospongia*, and *Streptelasma*. The rock is calcarenite with some fine-grained layers. The average thickness is about 50 feet, but the range of thickness is from 27 to 95 feet. The contact between the Lebanon and the lower Carters is disconformable. No brachiopods are recorded from the lower Carters.

The upper member of the Carters formation is composed mostly of thin-bedded limestone, dove colored, and with the layers often separated by thin shale partings. The rock contains *Tetradium cellulosum* in abundance. This is the part referred to the Lowville of New York by Ulrich and was the basis for identify-

ing the members of the Stones River group below the Carters as equivalent to the New York Chazy. Brachiopods from the upper Carters are:

Camerella bella Fenton
Chaulistomella lebanonensis Cooper
Chaulistomella sp. 1
Craniops attenuata Cooper (in Alabama)
Doleroides tennesseensis Cooper
Fascifera sulcata Cooper
Hesperorthis "tricenaria"
Opikina varia Cooper
Oxoplecia planulata Cooper (Alabama)
Sowerbyella subcarinata (Ulrich) (Alabama)
Strophomena filitexta = *S. auburnensis nasuta* Cooper (Sequatchie Valley)
S. platyumbona Cooper (Alabama)
Zygospira circularis Cooper

Correlation of Carters formation.—The Carters formation is identified in the Appalachian Valley and Sequatchie Valley with the Hardy Creek and Cane Creek formations of southwestern Virginia.

"Kimmswick" limestone.—Ulrich (1911, p. 310) reported Kimmswick limestone near Aspen Hill, Giles County, Tenn. This rock, which is a coarse calcarenite about 35 feet thick, contains the ball-cystid *Echinospaerites* and *Receptaculites oweni*, both characteristic of the Kimmswick of Missouri. C. W. Wilson (1949, p. 66), in mapping the Carters formation, discovered that the lower Carters member grades into the calcarenites of the "Kimmswick" and that typical Carters fossils occur in the Kimmswick facies as well as in the lower Carters facies. This, then, is corroboratory evidence that the Kimmswick of Tennessee equals Carters and that the Carters itself is of Trenton age. Brachiopods reported from the Tennessee "Kimmswick" are:

Rafinesquina cf. *R. minnesotensis*
Rhynchotrema minnesotensis
Strophomena cf. *S. scofieldi* = *Furcitella scofieldi* (Winchell and Schuchert)

Correlation of "Kimmswick" limestone.—It is suggested here that this "Kimmswick," which is a facies of the Carters, correlates with the Oranda formation of the Appalachian Valley. The latter formation also contains a large *Receptaculites* but is probably older than the Kimmswick of the Mississippi Valley which contains *Platystrophia*, a genus not yet taken in the Appalachians as low as the Oranda.

Hermitage formation.—The Carters is succeeded by a complete change of lithology and fauna. The Hermitage, as displayed in the vicinity of Woodbury, Cannon County, Tenn., introduces a fauna characterized by large *Dinorthis* and *Heterorthis clytie*. C. W. Wilson (1949, pp. 82-88) places this part of the Hermitage formation in the Curdsville member. The Curdsville fauna of Kentucky and the Appalachian Valley, however, is quite different from that of the Central Basin. In the Appalachians the Curdsville contains a large *Dinorthis*, to be sure, but it also is teeming with *Sowerbyella curdsvillensis* and *Hesperorthis tricenaria*. The assemblage, besides lacking *Heterorthis*, is quite different from

the fauna at the base of the Hermitage. According to McFarlan (1931, p. 50), the Hermitage of Kentucky is characterized by large *Dinorthis* and *Heterorthis*. It is the writer's belief that the correlation of the *Heterorthis* assemblage with the Curdsville is not correct. Hermitage brachiopods besides those listed are:

Dalmanella crassicostellata Cooper

D. sulcata Cooper

Dinorthis pectinella (Emmons)

Omiella ? *americana* Cooper

O. ? *planoconvexa* Cooper

Pionodema tennesseensis Cooper

Platystrophia extensa McEwen

Rafinesquina hermitagensis Bassler = *R. trentonensis* (Conrad) ?

Rhynchotrema "increbescens"

Rostricellula minuta Cooper

Zygospira "recurvirostris" (Hall)

WELLS CREEK BASIN

The Wells Creek Basin is a small cryptovolcanic structure located in southeastern Stewart County in north-central Tennessee. Bucher (1936, p. 1069) described the structure and some of the stratigraphy of the basin. C. W. Wilson (1949, p. 324-325) gives the most complete section and identifies the Ordovician formations for the first time. Most of the formations of the Stones River group are present, as follows:

Lower Carters member..... (100 feet, est.)

Lebanon limestone present

Ridley limestone present

Pierce limestone not recognized but probably present

Murfreesboro limestone present

The lowest formation rests on the Wells Creek dolomite of Canadian age and the lower Carters member is overlain by 100 feet (estimated) of Hermitage.

In 1903 Foerste (p. 705) applied the name "Wells" to limestones about 1¼ miles southwest of Cumberland City, along the railroad, about ½ mile south of the crossing of the Erin Pike. The fossils from these beds were identified as an upper Stones River assemblage. The brachiopods listed by Foerste are:

Acanthocrania cumberlandensis (Foerste)

Crania related to *setigera* but with surface spinose

Dalmanella subaequata var. = ? *Pionodema minuscula* Willard

Dinorthis deflecta = ? *Chaulistomella*

Hallina nicolleti = *Protozyga*

Orthis tricenaria = *Hesperorthis tricenaria* (Conrad)

**Plectambonites sericea* = *Sowerbyella*

**Rafinesquina minnesotensis* = *Öpikina*

Rhynchotrema related to *inaequivalvis* but with more triangular outline and with the sides more flattened, producing a more angular shell; probably identical with *Rh. orientalis* of Safford. This description suggests *Rostricellula compressa* Cooper.

**Strophomena incurvata* (*filitexta*)

Zygospira recurvirostris

This list is strongly suggestive of the Lebanon formation, but it is possible that some Carters is represented. In addition to the above fossils the writer is describing *Eoplectodonta foerstei* which is said to have come from the Lowville. It is probable that it was derived from a part of the column now referred to the Carters. Its occurrence is in accord with the correlation of Carters with the Oranda.

HIGH BRIDGE, CENTRAL KENTUCKY

The sequence in the bluffs along the Kentucky River south of Lexington, Ky., was described by A. M. Miller (1905), A. C. McFarlan (1931, p. 49), and G. G. Huffman (1945, pp. 165-168). The "Highbridge Series" is divided into three formations from the bottom: Camp Nelson, Oregon, and Tyrone.

Camp Nelson formation.—This formation consists of 315 feet of mostly dove-gray limestone, massively bedded in the lower 100 feet but becoming thinner bedded above. Important among the fossils reported from this formation is *Cryptophragmus antiquatus* (Raymond) which "forms a prominent zone (65 feet or more) in the upper 90 feet." The following brachiopods are reported:

- Ancistrorhyncha* sp. = *Ancistrorhyncha australis* (Foerste)
- Camarotoechia plena* (Hall) = *Rostricellula* sp.
- Chaulistomella lebanonensis* Cooper
- Doleroides* sp.
- Glyptorthis* sp.
- Multicostella* (?) sp. aff. *M. platys* (Billings) = *Chaulistomella* sp.
- Öpikina eximia* Cooper
- Öpikina* sp. cf. *O. minnesotensis* (N. H. Winchell)
- Öpikina* sp. cf. *Ö. transitionalis* (Okulitch)
- Pionodema minuscula* Willard
- Pseudolingula* ? *sculptata* Cooper
- Rostricellula compressa* Cooper
- Strophomena* sp.
- Zygospira lebanonensis* Cooper

Correlation of Camp Nelson formation.—The presence of *Cryptophragmus* in the upper part of the Camp Nelson formation is a clue to the correlation. This combined with the Wardell-Witten types of brachiopods indicates that the Camp Nelson is equivalent to the Ridley-Lebanon of the Central Basin. *Cryptophragmus* occurs in the lower part of the Witten and in the middle of the Lebanon. The correlation is thus with the lower Witten and part of the Wardell, a correlation that is corroborated by *Öpikina* and *Ancistrorhyncha*. *Cryptophragmus* occurs in the middle of the Lebanon; therefore, the correlation is with the lower Lebanon and probably part of the Ridley.

The above correlation is possible but may not be the true one. Inasmuch as *Cryptophragmus* is commonly tied to the calcarenite facies, it may occur in any part of the formation. If this be true, the correlation of the Camp Nelson is more probably with Witten and Lebanon; Wardell and Ridley may or may not be represented. The fossils listed by Huffman and recorded above are more suggestive of high Lebanon than they are of any other part of the column, but the thickness of the Camp Nelson is far greater than that of the Lebanon. *Sower-*

byella is not reported from the Camp Nelson and is rare in the upper Lebanon. The Camp Nelson probably thins toward the Central Basin of Tennessee and could thus be the equivalent of the Lebanon alone. The Camp Nelson formation lithologically is like the Lebanon and has *Camarocladia* markings like that formation. On the chart the correlation is indicated as mainly with the Lebanon toward the Central Basin and with Witten and part of the Wardell to the east.

Oregon formation.—This formation consists of 35 feet of cream-colored dolomite without fossils. The bed has been correlated with the lower Carters.

Tyrone formation.—This formation consists of 75 feet of dove-gray limestone with conchoidal fracture and birdseye-type calcite rods. The formation has three metabentonites, one near the base, a second 55 feet above the base, and the third at the top just under the overlying Curdsville formation. Fossils are not common. The following brachiopods occur:

Idiospira panderi (Billings)

Strophomena auburnensis nasuta Cooper

**Strophomena* cf. *S. dignata* Fenton

**S.* cf. *S. plattinensis* Fenton

Zygospira sp.

Correlation of Tyrone formation.—The Tyrone formation is correlated with the Cane Creek formation of southwestern Virginia and the upper Carters of the Central Basin of Tennessee. This correlation has hitherto been accomplished more by bentonites (Huffman, 1945) than by fossils because so few fossils have been taken from the formation. However, the strophomenoids are of Trenton types and the *Zygospira* indicates correlation with the range of Witten to Cane Creek.

6. THE DISTURBED AREA AT KENTLAND, INDIANA

An area of disturbed Ordovician strata occurs in the north half of sec. 25, T. 27 N., R. 9 W., along the south line of Newton County about 3 miles east of Kentland. Shrock (1937) describes this area in great detail. The Means Quarry is the westernmost opening and the McKee Quarry is the easternmost one. The middle exposure is the McCray Quarry. The sequence is divided into 12 divisions: The lowest is the Prairie du Chien and the highest is in the Pleistocene. Divisions 1 to 9 are of interest in this discussion.

Division 1.—Consists of 15 feet of sandstone assigned to the St. Peter but no brachiopods are reported.

Division 2.—White quartzose sandstone with a few beds containing many mollusks of a few kinds. This bed is referred by Shrock to the Glenwood shale and sandstone of Illinois.

Division 3.—Uncertain.

Division 4.—36 feet of light-buff, dolomitic, arenaceous limestone and sandstone containing *Leperditia fabulites*.

Division 5.—Blue-gray to light-brown somewhat dolomitic limestone, fine-grained and arenaceous. Thickness about 20 feet. The following brachiopods are reported:

Pholidops trentonensis minor = *Craniops minor* (Winchell and Schuchert)

Pionodema cf. *conradi* = *P. conradi* (N. H. Winchell)

Rafinesquina minnesotensis = *Öpikina minnesotensis* (N. H. Winchell)
Rafinesquina n. sp. = *Öpikina*
Rhynchotrema minnesotense = *Rostricellula minnesotensis* (Sardeson)
Strophomena plattinensis = *S. plattinensis* Fenton
S. p. crassa = *S. p. crassa* Raasch
Valcourea deflecta = *Campylorthis deflecta* (Conrad)
Zygospira saffordi = *Hallina saffordi* Winchell and Schuchert

Division 6.—Thirty-six feet of light-brown to buff dolomitic limestone, fine-granular and fairly even textured in thick beds. Two brachiopods, *Hesperorthis tricenaria* and *Valcourea deflecta* = *Campylorthis*, are reported.

Division 7.—Limestone, dolomitic, moderately granular and heavy bedded with numerous *Cryptophragmus antiquatus*. The division is about 11 feet thick. Brachiopods reported are:

Rhynchotrema minnesotensis = *Rostricellula minnesotensis* (Sardeson)
Strophomena auburnensis = *S. auburnensis* Fenton
Valcourea deflecta = *Campylorthis deflecta* (Conrad)

Division 8.—Somewhat dolomitic limestone, blue-gray, white-weathering, thin-bedded, semilithographic, separated by films of black or gray somewhat carbonaceous shale. The division is 58 feet thick. Fossils are abundant and include the following brachiopods:

Crania setigera = *Acanthocrania setigera* (Hall)
Glyptorthis bellarugosa = *G. bellarugosa* (Conrad)
Hesperorthis tricenaria = *H. tricenaria* (Conrad)
Leptaena charlottae = *Bellimurina charlottae* (Winchell and Schuchert)
Rafinesquina cf. *hermitagensis* = *R. trentonensis* (Conrad)
R. minnesotensis = *Öpikina minnesotensis* (N. H. Winchell)
Rhynchotrema minnesotensis = *Rostricellula minnesotensis* (Sardeson)
Strophomena trentonensis Winchell and Schuchert
Zygospira recurvirostris (Hall)

Division 9.—Sixty-five feet of cherty, dolomitic limestone containing *Columaria halli* in abundance. *Hesperorthis tricenaria* and *Strophomena trentonensis* are the only brachiopods reported.

Overlying Division 9 are beds referable to Trenton rocks and higher.

Correlation of strata of Kentland area.—According to Shrock and Raasch (1937), Divisions 4 to 6 are referable to the Platteville formation; Division 7 is assigned to the Lowville (=Carters). Division 8 is referred to the Black River but its lower part is thought to be Platteville. Division 9 is Black River-Trenton by its position under Division 10, which is assigned to the Galena formation.

Closer correlations may actually be possible in some instances, but they will only slightly change the picture as given by Shrock and Raasch. Divisions 4 to 6 contain a number of brachiopods of which *Pholidops* [= *Craniops*] *trentonensis minor* is important. In Minnesota this species occurs in the *Ctenodonta* bed of the Guttenberg member. In Oklahoma *Craniops* occurs in the upper Bromide of about Ridley age. The presence of *Rhynchotrema* [= *Rostricellula*] *minnesotensis* and *Pionodema conradi* suggest a somewhat earlier dating than Gutten-

berg. The Mollusca, particularly *Salterella* [*Polylophia*] *billingsi*, suggest correlation with the Murfreesboro limestone of Tennessee. The ensemble seems best placed in the position of the Platteville.

Abundance of *Cryptophragmus antiquatus* in Division 7 suggests assignment to the Pamela, Gratton, or Witten limestones, all of which contain this peculiar fossil. The numerous species that occur in this division besides the *Cryptophragmus* do not help in correlating with the Pamela because so few species are known from that formation. Not much help is to be found in these fossils of Division 7 in comparing with the Witten fauna because no important Witten elements are included. The division could correlate with the Ridley or Wardell as well as Witten. *Strophomena auburnensis* suggests correlation with the Guttenberg.

Division 8, if the reported fossils are correctly identified, is probably assignable to the Guttenberg member of the Decorah formation. This is based on the presence of *Rafinesquina* cf. *hermitagensis* which seems to be identical with *R. alternata* Conrad=*R. trentonensis* (Conrad). This division also contains *Leptaena charlottae*=*Bellimurina*, which occurs in the Guttenberg of Minnesota.

7. THE MISSISSIPPI VALLEY

The Ordovician formations of the Mississippi Valley are best discussed in two geographic areas: the upper Mississippi Valley and the middle Mississippi Valley. Embraced in the former are northeastern Iowa, northwestern Illinois, southeastern Minnesota, and southwestern Wisconsin. The latter area covers parts of Missouri, adjacent Illinois, and Arkansas.

UPPER MISSISSIPPI VALLEY

The section in this part of the Mississippi Valley consists of the following section from the bottom up: St. Peter sandstone, Platteville limestone, Decorah shale, and Prosser limestone.

St. Peter sandstone.—This is a widespread formation throughout the Mississippi Valley and in the subsurface of several States as far east as Indiana and Kentucky and west to Oklahoma. The St. Peter has generally been regarded of Marmor (Chazyan) age, but no clear faunal evidence has ever been accumulated to prove this point. The formation may actually be a transgressing sandstone and of different age in different places as indicated on the chart. The known fauna consists mostly of mollusks, which are the types of animal to be expected in a sandstone environment. Sardeson (1896) lists the fauna which includes three brachiopods: ? *Crania reversa* Sardeson, *Lingulella morsii* (N. H. Winchell), and *Orthis* [*Doleroides*] *pervetus* ? Conrad. If the latter identification be correct, the formation would be high Porterfield and not equal to Marmor (Chazyan), at least in the upper Mississippi Valley.

Platteville formation (group of Templeton and Willman).—The Platteville limestone occurs in all the States named and consists of several members from the bottom up: Glenwood shale, Pecatonica limestone, McGregor limestone Mifflin limestone, and Magnolia limestone.

Glenwood member of Platteville formation.—This member consists of greenish shale and ranges in thickness from 0 to 10 feet but is generally from 4 to 6 feet thick. This formation, like the St. Peter below it, is widespread and may be of different age in different places. In the bluffs on the Mississippi River, Minneapolis, thin layers of dolomite in the green shale produced a few fossils that ally it with the overlying Platteville: *Campylorthis deflecta* (Conrad).

Templeton and Willman (1952, p. 6) state that the equivalents of the Glenwood attain a thickness of 400 feet.

Pecatonica member of Platteville formation.—This is the Lower Buff division of the early reports. It consists of dense, blue, buff-weathering, heavy-bedded magnesian limestone or dolomite. This member succeeds the Glenwood in northern Illinois, southwestern Wisconsin, and northeastern Iowa. Its maximum thickness, about 30 feet, is in Illinois and it thins to disappearance to the north. Few fossils have been listed, mostly Mollusca.

McGregor member of Platteville formation.—This term was proposed by Kay (1935, p. 286) to include the "Blue beds" and "Upper Buff" beds of the older reports. In Minnesota the *Vanuxemia* bed is partially equivalent to the "Blue beds." The brachiopods listed for the McGregor in Minnesota are:

Acanthocrania granulosa (N. H. Winchell)

Crania setigera Hall = *Acanthocrania setigera* (Hall)

Lingula elderi Whitfield = *Pachyglossa elderi* (Whitfield)

Orthis tricenaria Conrad = *Hesperorthis concava* Cooper

O. (Dalmanella) subaequata Conrad (not seen)

O. (D.) subaequata conradi N. H. Winchell = *Pionodema conradi* (N. H. Winchell)

O. (D.) subaequata perveta Conrad = *Doleroides pervetus* (Conrad)

O. (Dinorthis) deflecta Conrad = *Campylorthis deflecta* (Conrad)

O. (Hebertella) bellarugosa Conrad (not seen)

Petrocrania dixonensis Cooper

Rafinesquina minnesotensis N. H. Winchell = *Öpikina minnesotensis* (N. H. Winchell)

Rhynchotrema minnesotensis Sardeson = *Rostricellula minnesotensis* (Sardeson)

Siphonotreta ? minnesotensis Hall

Skenidioides anthonensis (Sardeson)

Sowerbyella sp.

Strophomena incurvata (Shepard) = *S. plattinensis* Fenton

S. plattinensis crassa Raasch

Trematis huronensis ? Billings

Trigrammaria winchelli (Hall and Clarke)

**Zygospira recurvisrostris* (Hall)

Z. (Hallina) nicolleti Winchell and Schuchert = *Protozyga nicolleti* (Winchell and Schuchert)

Stauffer and Thiel (1941, p. 77) state that although remnants of the Pecatonica and Magnolia members appear in Minnesota, they are not sufficiently clear to separate, and therefore the term "McGregor" as defined by Kay is preferred. Bays and Raasch (1935, p. 298) excluded the "Upper Buff" beds from the McGregor and proposed Magnolia for them and other overlying beds. Bays (1938, p. 269) rejected McGregor and recognized Mifflin and Magnolia above the Pecatonica. Satisfactory faunal lists have never been published for these members.

Mifflin member of Platteville formation.—This name was proposed by C. A. Bays for 17½ feet of thin-bedded limestone exposed on the Pecatonica River at Mifflin, Iowa County, Wis. This member underlies the Magnolia and overlies the Pecatonica members. No fossils are listed.

Magnolia member of Platteville formation.—This name is applied by Bays and Raasch (1935, p. 298) to the "Upper Buff" division of earlier authors. These are light-buff, moderately thick-bedded dolomites, thickest in south-central Wisconsin.

Doleroides ottawanus Wilson ?

S. plattinensis Fenton

Obolellina dixonensis Cooper

S. plattinensis crassa Raasch.

Strophomena auburnensis impressa Raasch

Templeton and Willman (1952, fig. 3) divide the Magnolia member into two formations which are themselves many times divided into members. The Grand Detour formation (with seven members) attains a thickness of slightly more than 50 feet of dolomite or limestone, thicker bedded than the Mifflin below. The Nachusa formation (of three members) is 19 feet thick, of dolomite or limestone, and containing *Foerstephyllum* and *Tetradium*. No brachiopods are recorded from either formation.

Quimbys Mill member of Platteville formation.—This name was proposed by Agnew and Heyl (1946, p. 1585) for the "Glass Rock" between the Spechts Ferry and the McGregor member of the Platteville formation. It consists of limestone and dolomite, 12 feet thick at the type section, at old Quimby's Mill in SE¼SE¼ sec. 11, T. 1 N., R. 1 E., near the Fever River at Etna, Wis. The formation abounds in *Öpikina*. It is placed with the Spechts Ferry by Templeton and Willman (1952, fig. 3).

Correlation of Platteville formation.—The Platteville formation abounds in *Strophomena*, *Öpikina*, *Pionodema*, and *Doleroides*. The combination appears in the Chaumont and extends into the early Rockland. In the Appalachians this combination comes in with the Wardell and continues through the Lebanon. The writer, therefore, correlates the Platteville with Chaumont and part of the Rockland.

Decorah formation.—This formation is composed chiefly of greenish shale with thin limestone layers. According to Kay (1935, p. 289) "Southward, the calcareous shales pass into limestones, of which the lower, the Guttenberg member, are gray with brown, 'oil rock' partings, and the upper, the Ion member, bluish, containing intercalated greenish, calcareous shales. Northward from the type locality, the members persist as greenish, calcareous shales." Three members have been distinguished from the bottom up: Spechts Ferry, Guttenberg, and Ion.

Spechts Ferry member of Decorah formation.—Blue or green laminated shale with a thickness from 5 to 8 feet from Platteville, Wis., to southern Minnesota. To the north it thickens to nearly 40 feet. In Minnesota it is the *Stictoporella* bed of the Minnesota Survey. The following brachiopods are reported:

Crania halli Sardeson = *Petrocrania halli* (Sardeson)

C. setigera Hall = *Acanthocrania setigera* (Hall)

Dalmanella perveta (Conrad) = *Doleroides pervetus* (Conrad)

D. subaequata (Conrad) = *Pionodema subaequata* (Conrad)

Doleroides gibbosus (Billings)

D. medius (Winchell) = *D. winchelli* Cooper

Lingula elderi Whitfield = *Pachyglossa elderi* (Whitfield)

Orthis tricenaria (Conrad) = *Hesperorthis* sp.

Pionodema uniplicata Cooper

Plectambonites sericea (Sowerby) = *Sowerbyella* (not seen)

Rostricellula ainsliei (N. H. Winchell)

R. minnesotensis (Sardeson)

Strophomena incurvata (Shepard) = *S. auburnensis* Fenton

Trematis huronensis ? Billings = *T. punctostriata* Hall

T. minnesotensis Sardeson

Zygospira recurvirostris (Hall) (not seen)

Correlation of Spechts Ferry member.—This member is difficult to place because it contains elements of the fauna below but also elements of the Guttenberg above, such as *Pionodema subaequata*. The abundance of large *Pionodema* and *Doleroides* suggests assignment to upper Platin of Missouri and to the Carters of West Tennessee. This correlation is also borne out by the large *Trematis* which occurs in the top of the Platin.

Guttenberg member of Decorah formation.—In northern Illinois this is the "oil rock"; in northern Iowa it is composed of grayish, shaly limestone about 13 feet thick; in Minnesota the member consists of the *Rhinidictya* bed composed of soft, dark-greenish shale, and the *Ctenodonta* bed characterized by pelecypods. Brachiopods occurring in the *Rhinidictya* bed are:

Crania setigera Hall = *Acanthocrania setigera* (Hall)

Craniella ? *ulrichi* Hall = *Petrocrania ulrichi* (Hall)

Dalmanella hamburgensis Winchell and Schuchert (not Walcott) = *D. winchelli* Cooper

Idiospira panderi (Billings)

Leptaena charlottae Winchell and Schuchert = *Bellimurina charlottae* (Winchell and Schuchert)

Lingula clathrata Winchell and Schuchert = *Westonia clathrata* (Winchell and Schuchert)

L. eva Billings

Orthis tricenaria Conrad = *Hesperorthis tricenaria* (Conrad)

O. (Dalmanella) subaequata perveta Conrad = *Doleroides pervetus* (Conrad)

O. (Hebertella) bellarugosa Conrad = *Glyptorthis bellarugosa* (Conrad)

Pionodema subaequata (Conrad)

P. uniplicata Cooper

Plectambonites sericea Sowerby = *Sowerbyella punctostriata* (Mather)

Rafinesquina minnesotensis inquassa Sardeson = *Opikina inquassa* (Sardeson)

R. prestonensis Salmon

R. sinclairei Salmon

R. trentonensis (Conrad)

Rhynchotrema ainsliei N. H. Winchell = *Rostricellula ainsliei* (N. H. Winchell)

R. minnesotensis Sardeson = *Rostricellula minnesotensis* (Sardeson)

Rostricellula pulchra Cooper

Schizocrania filosa Hall

Strophomena delicatula Fenton

S. dignata Fenton

S. incurvata (Shepard) = *S. auburnensis* Fenton

Trematis huronensis ? Billings

Zygospira recurvirostris (Hall) (not seen)

The brachiopods recorded from the *Ctenodonta* bed are:

Crania setigera Hall = *Acanthocrania setigera* (Hall)

Leptaena charlottae Winchell and Schuchert = *Bellimurina charlottae* (Winchell and Schuchert)

Orthis tricenaria Conrad = *Hesperorthis tricenaria* (Conrad)

Pholidops trentonensis minor Winchell and Schuchert = *Craniops minor* (Winchell and Schuchert)

Plectambonites sericea Sowerby = *Sowerbyella punctostriata* (Mather)

Strophomena incurvata (Shepard) = probably *S. auburnensis* Fenton

Zygospira recurvirostris (Hall)

Correlation of Guttenberg member.—The Guttenberg brings the first appearance in the Upper Mississippi Valley of *Rafinesquina* ss., *Dalmanella* ss., and the large *Sowerbyella*. The formation is correlated with the Oranda of the Appalachians and the Carters of West Tennessee. The Barnhart of Missouri is thought to be a southward extension of the Guttenberg. It is uncertain in the writer's mind whether or not the Guttenberg is equivalent to lower Curdsville. That formation has the large *Sowerbyella* and early form of *Rafinesquina*. The Oranda is an earlier-deposited formation than the Curdsville and also contains large *Sowerbyella* and *Rafinesquina*. The Collierstown, probably the lateral equivalent of the Oranda, contains the *Rafinesquina* and other fossils to establish this correlation.

Ion member of Decorah formation.—The 16 feet of shale and limestone forming the Ion member at its type section passes into limestone to the south and into greenish shale to the north. In Minnesota this member includes the *Phylloporina* and fucoid beds. These contain the following brachiopods:

Dinorthis sweeneyi (Winchell)

Glyptorthis subcircularis Cooper

Orthis tricenaria Conrad = *Hesperorthis colei* Cooper

O. (Dalmanella) hamburgensis ? Walcott = *D. winchelli* Cooper

O. (D.) testudinaria Dalman = *Paucicrura rogata* (Sardeson)

O. (D.) subaequata circularis N. H. Winchell = *Pionodema circularis* (N. H. Winchell)

O. (Hebertella) bellarugosa Conrad = *Glyptorthis bellarugosa* (Conrad)

Pionodema minnesotensis Cooper

P. uniplicata Cooper

Plectambonites sericea Sowerby = *Sowerbyella monilifera* Cooper

Rafinesquina alternata Conrad = *R. trentonensis* (Conrad)

R. minnesotensis iniquassa Sardeson = *Opikina lirata* Cooper

Rhynchotrema inaequivalvis Castelnau = *R. wisconsinense* Fenton and Fenton

Rostricellula colei Cooper

Sconidium anthonensis Sardeson = *Skenidioides anthonensis* (Sardeson)

Strophomena incurvata (Shepard) = *S. musculosa* Fenton

S. septata Winchell and Schuchert

S. trentonensis Winchell and Schuchert

Zygospira recurvirostris (Hall)

Correlation of Ion member.—Kay (1937, p. 294) correlates the Ion member with the lower part of the Hull formation of Ontario, Quebec, and New York.

This member with its true *Rhynchotrema*, *Rafinesquina*, and large *Sowerbyella* is of about the same age as the preceding member and is correlated with part of the Kimmswick of Missouri and Curdsville of West Tennessee and Kentucky.

Prosser formation.—The Ion member of the Decorah formation is overlain by rocks lithologically and faunally quite distinct from the underlying shales. The Prosser formation overlying the Ion member is thin-bedded limestone and calcareous shale abounding in fossils. The species occurring in this formation introduce new elements for the upper Mississippi Valley such as *Vellamo*, *Platystrophia*, *Furcitella scofeldi* (Winchell and Schuchert). These indicate correlation with the Kimmswick of Missouri and the Sherman Fall of New York and Ontario, but these elements do not occur in the Appalachians.

Obolellina parva (Whitfield)

Parastrophina bernensis (Sardeson)

P. rotundiformis Willard

Philhedra depressa Cooper

Rostricellula acutiplicata Cooper

Rostricellula sp. 3

The Salona of Virginia and Pennsylvania contain many Kimmswick elements such as the ball cystid *Echinosphaerites*, large *Parastrophina*, large *Sowerbyella*.

Templeton and Willman (1952, p. 6 and fig. 3) propose the name Dunleith for the combined Prosser and Ion of Wisconsin and Illinois and split their new formation into 10 members.

UPPER MISSISSIPPI VALLEY FORMATIONS NOT IN GENERAL USE

Lowell Park member of Platteville formation.—This name was applied by Knappen (1926, p. 54) to interbedded gray and buff heavy-bedded limestone and coarse-grained, yellow-brown porous dolomites like the overlying Galena. The formation is 20 to 30 feet thick. It overlies the "blue" limestone and underlies the Galena and thus forms the upper member of the Platteville. Brachiopods listed are:

Leptaena charlottae Winchell and Schuchert

Orthis tricenaria Conrad

Rafinesquina minnesotensis (N. H. Winchell)

Strophomena incurvata (Shepard)

S. trentonensis Winchell and Schuchert

Minneapolis limestone.—This was proposed by Sardeson for the basal bed of the Beloit formation or lower Platteville. (See Wilmarth, 1938, p. 1381.)

Beloit dolomite formation.—This is another name proposed by Sardeson (1896) which includes the equivalents of the Decorah and Platteville. (See Wilmarth, 1938, p. 157.)

MIDDLE MISSISSIPPI VALLEY

In this part of the Valley the section, in ascending order, consists of the Buffalo River series, Rock Levee formation, Plattin group, Decorah formation, Auburn chert, and Kimmswick limestone. Some members of the Buffalo River series are well displayed in Ste. Genevieve County, Mo., and in the vicinity of Cape Girardeau.

Buffalo River series (originally Big Buffalo series, but the name of the Big Buffalo River, after which the group is named, was changed by the Geo-

graphic Board to Buffalo River [Wilmarth, 1938, pp. 181, 182]).—The Buffalo River series consists, in ascending order, of the Everton, St. Peter, Dutchtown, and Joachim formations. These formations have not yielded brachiopods in the lower Mississippi area except *Lingulella* sp. 7 from the Dutchtown formation and are therefore not discussed in this paper. Their correlation is based on position in the section and fossils other than brachiopods. (Dake, 1921, pp. 14-28; Weller and St. Clair, 1928, pp. 91-104; for Dutchtown formation, see Cullison, 1938, pp. 219-228.)

Rock Levee formation.—This formation was proposed by Grohskopf (1948, p. 360) for part of the limestones referred by Ulrich (1939, p. 109) to the Murfreesboro formation in the vicinity of Cape Girardeau in Missouri. This formation takes some thickness from the underlying Joachim and the overlying Platin formations. Knowledge of this formation is derived from surface exposures and a study of deep wells. The name is from a siding on the St. Louis-San Francisco RR. in NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 24, T. 30 N., R. 13 E., Cape Girardeau County. In the type area the thickness in wells is 270 feet but only about 50 feet appear on the outcrop at the junction of U. S. Highway 61 and Missouri Highway 74. The formation contains an upper zone 70 feet thick characterized by cystid plates; the remainder of the formation contains silt and sand in the residues. The formation is composed mostly of buff and gray dolomitic rock but the upper part is fine gray limestone. Fossils are not abundant, but the upper layers contain *Ancistrorhyncha missouriensis* Cooper. Correlation is with the Peery limestone formation in the Appalachians because of similarity of the *Ancistrorhyncha* occurring in the two formations.

PLATTIN GROUP.—The rocks to which this name is applied formerly had only formational rank. Larson (1951, pp. 2041-2075) recently raised them to the status of a group. Larson recognized four formations in ascending order: Bloomsdale, Beckett, Hager, and Macy. The Platin group is prominent in eastern Missouri from Scott County in the south to Ralls County at the north, and westward to eastern Callaway County. The group thins to the north, and all the member formations thin in the same direction. The maximum thickness is about 300 feet; near Mineola in its western range only 31 feet of the lower beds is exposed.

Bloomsdale formation.—This is composed mainly of calcilutite and fine-grained dolomite with interbeds of oolite and limestone pebble conglomerate. At its thickest, near Beckett Mills, Ste. Genevieve County, it is mostly 59 feet of calcilutite but thins to about 12 feet at Kings Lake in Lincoln County. The formation is sparsely fossiliferous as usual in calcilutites and, as usual in that lithology, *Ancistrorhyncha* (= *A. costata* Ulrich and Cooper) is common. *Rhynchotrema* (probably *Rostricellula*) sp. is also reported. Correlation is suggested with the Wardell formation.

Beckett formation.—This is a fine-textured limestone with intraformational calcarenite and carbonate pebble conglomerate. Chert is abundant in the upper part. The lower Beckett is pinkish-brown, fucoidal, and fine-textured. This part is absent north of Herculeum, Jefferson County. The Upper Beckett contains

many layers of calcarenite, limestone pebble conglomerate, and brown chert nodules. The formation attains a thickness of 108 feet in Cape Girardeau and Perry Counties but thins to 75 feet at Kings Lake. Twenty-eight feet is exposed at Mineola, but there the Plattin has been eroded to this level. Few good collections were taken by Larsen from this formation, but he reports *Cryptophragmus antiquatus* (Raymond) among other fossils. Brachiopods listed are:

Ancistrorhyncha sp.

? *Camerella* sp.

Campylorthis deflecta (Conrad)

Glyptorthis bellarugosa (Conrad)

Öpikina subtriangularis Wilson

Ö. cf. *Ö. wagneri* (Okulitch)

Öpikina sp.

**Parastrophina hemiplicata* (Hall)

Rostricellula sp.

Correlation is suggested with the Witten of the Appalachians and Platteville of the upper Mississippi Valley.

Hager formation.—Generally fine-textured limestone named after Hager School in Perry County. Three facies are recognizable: The major part is slabby olive-gray limestone with buff-weathering partings; calcilitite and calcarenite make up the remainder. The first facies is mainly in the thicker sections on the south. The calcilitite generally overlies the slabby limestone and both grade laterally into calcarenite. The formation is 85 to 93 feet thick in Cape Girardeau County and thins out near the latitude of St. Louis. The slabby limestone facies contains abundant fossils:

Campylorthis deflecta (Conrad)

**Glyptorthis bellarugosa* (Conrad)

**Hesperorthis tricenaria* (Conrad)

**Öpikina* cf. *Ö. transitionalis* (Okulitch)

**Ö. cf. Ö. wagneri* (Okulitch)

Öpikina sp.

Orbiculoidea sp.

Rostricellula cuneiformis (Fenton and Fenton)

? *R. minnesotensis* (Sardeson)

? *Rostricellula* sp.

Strophomena cf. *S. delicatula* Fenton

S. dignata Fenton

S. exigua Fenton

S. plattinensis Fenton

Strophomena sp.

Zygospira recurvirostris (Hall)

Correlation of Hager formation.—Presence of *Campylorthis* is a link to the Platteville limestone of the upper Mississippi Valley. The formation is also linked to the Lebanon of the Central Basin of Tennessee by the *Zygospira*.

Macy formation.—Named after Macy in Ste. Genevieve County, Mo. The formation is 87 feet thick at the type locality and is slightly thicker in Cape Girardeau County. It thins to a little more than 40 feet in Lincoln County but is absent in Callaway County to the west. The formation is mostly of fine-textured limestone divided into two members: Hook below and Zell above.

Hook member of Macy formation.—This member is composed of fine, yellowish-brown fucoidal limestone with irregular buff-weathering dolomitic partings. The member is 13 to 15 feet thick near Kings Lake in Lincoln County, Mo., and thickens to 40 feet in Perry County. The following brachiopods are reported:

Campylorthis deflecta (Conrad)

Hesperorthis tricenaria (Conrad)

Öpikina sp.

Zell member of Macy formation.—This member is named from the town of Zell, in Ste. Genevieve County, Mo., and consists of fine-textured limestone with green shale partings. It is 32 feet thick at the type locality and contains nodular and bedded brown chert. The member is 52 feet thick near Altenburg in Perry County but thins to 29 feet at Kings Lake. It is 22 feet thick just west of St. Louis. Fossils, including brachiopods, are abundant in the Zell:

| | |
|--|---|
| <i>Ancistrorhyncha</i> sp. | <i>R. cf. R. missouriensis</i> (Fenton and Fenton) |
| <i>Camerella bella</i> Fenton | <i>R. plattinensis</i> Fenton |
| <i>C. gregeri</i> Cooper | <i>Rostricellula</i> sp. |
| <i>Campylorthis deflecta</i> (Conrad) = <i>C. subplana</i> Cooper | <i>Schizocrania filosa</i> (Hall) |
| <i>Doleroides gibbosus</i> (Billings) | <i>Sowerbyella punctostriata</i> (Mather) |
| <i>D. cf. D. pervetus</i> (Conrad) = <i>D. missouriensis</i> Cooper | <i>Strophomena auburnensis</i> Fenton |
| * <i>Glyptorthis bellarugosa</i> (Conrad) | <i>S. delicatula</i> Fenton |
| <i>Hesperorthis tricenaria</i> (Conrad) | <i>S. dignata</i> Fenton |
| * <i>Öpikina septata</i> ? Salmon | <i>S. exigua</i> Fenton |
| * <i>Ö. transitionalis</i> (Okulitch) | <i>S. inconsueta</i> Fenton |
| <i>Öpikina</i> sp. | <i>S. musculosa</i> Fenton |
| <i>Pionodema subaequata</i> (Conrad) | <i>S. plattinensis</i> Fenton |
| <i>Protozyga rotunda</i> Cooper | <i>S. winchelli</i> Hall and Clarke |
| <i>Rhynchotrema</i> sp. | <i>Strophomena</i> sp. |
| <i>Rostricellula cuneiformis</i> (Fenton and Fenton) | <i>Trematis foerstei</i> Cooper |
| | <i>Zygospira recurvirostris</i> (Hall) |
| | <i>Z. variabilis</i> Fenton |

Correlation of Macy formation.—The combination of genera and species in this formation indicates a correlation with the Carters limestone formation of the Central Basin of Tennessee and with the Spechts Ferry member of the Decorah formation. The Carters contains *Camerella bella*, *Doleroides*, *Pionodema subaequata*, and *Strophomena* suggestive of *S. auburnensis*.

Barnhart formation.—This name is here proposed for the "Decorah" of Missouri which overlies the Plattin group and underlies the Kimmswick formation. The type section is at Koch Valley School on U. S. Highway 61-67, 2 miles south of Barnhart, Kimmswick (15') Quadrangle. Here the formation consists of about 20 feet of greenish shale with interbedded thin limestones, all abundantly fossiliferous. The following species were collected:

| | |
|--|---|
| <i>Campylorthis subplana</i> Cooper | <i>R. missouriensis</i> (Fenton and Fenton) |
| <i>Hesperorthis tricenaria</i> (Conrad) | <i>Sowerbyella</i> sp. |
| <i>Pionodema subaequata</i> (Conrad) | <i>Strophomena delicatula</i> Fenton |
| <i>Protozyga rotunda</i> Cooper | <i>S. dignata</i> Fenton |
| <i>P. superba</i> Cooper | <i>Trematis foerstei</i> Cooper |
| <i>Rafinesquina sinclairi</i> Salmon | <i>Zygospira</i> sp. |
| <i>Rostricellula cuneiformis</i> (Fenton and Fenton) | <i>Z. lebanonensis</i> Cooper |

Correlation of Barnhart formation.—Although the lower shaly part of this formation was correlated with the Spechts Ferry member of the Decorah formation by Kay (1935, p. 288), the fossils collected by the writer from the lower and upper parts indicate equivalence with the Guttenberg member of the Decorah formation rather than the Spechts Ferry. This is indicated by the great abundance of *Pionodema*, *Rafinesquina*, large *Sowerbyella*, and *Zygospira*. The writer failed to find *Doleroides* in the few localities visited.

Auburn chert.—Residual chert in Lincoln County, Mo., contains numerous fossils listed by E. B. Branson (1909) and A. F. Foerste (1920). The brachiopods in the fauna are:

Dalmanella subaequata (Conrad) = *Pionodema subaequata* (Conrad)

D. testudinaria (Dalman) = *Paucicrura rogata* (Sardeson)

Hallina globularis Cooper

Idiospira panderi (Billings)

Lingula sp.

Orthis tricenaria Conrad = *Hesperorthis tricenaria* (Conrad)

Paucicrura rogata (Sardeson)

Strophomena incurvata (Shepard) = *S. auburnensis* Fenton

Rafinesquina mimesotensis (N. H. Winchell) = *Opikina*

R. sinclairi Salmon

Zygospira recurvirostris (Hall)

Z. nicolleti Winchell and Schuchert = *Protozyga superba* Cooper

Correlation of Auburn chert.—It has been suggested that the Auburn chert should be included in the Plattin group (Bradley, 1925, p. 66), but the brachiopods are not in accord with this suggestion from what is now known about the Auburn fauna. The presence of *Rafinesquina* indicates a higher correlation. It is here suggested that this formation may be chertified Decorah of Missouri = Barnhart formation, rather than Plattin and that the correlation should be with the Guttenberg member of the Decorah of the upper Mississippi Valley.

NORTHERN ARKANSAS

In the Eureka Springs, Harrison, and Yellville Quadrangles and adjacent areas to the east, the Buffalo River group is well exhibited. The section here from the bottom up is: Everton, Jasper, St. Peter, Joachim, and Plattin formations. As in the Missouri section, fossils are rare and brachiopods are not known from the Buffalo River group except in the Everton-Jasper limestones.

Everton-Jasper formation.—According to McKnight (1935, p. 40) the Jasper limestone has a maximum thickness of 50 feet and is indistinguishable from denser phases of the Everton limestone below. The Jasper was originally thought to be above the Joachim and St. Peter formations, but McKnight indicates that these formations were incorrectly identified in the Eureka Springs-Harrison Folio. The rocks so identified in reality are only parts of the Everton. McKnight further states that according to present evidence the Jasper limestone "interfingers with the dolomitic facies in the upper part of the Everton and should be considered a member of the Everton." The following brachiopod was found in the Jasper at Pindall:

Onychoplecia matutina Cooper

Correlation of Everton-Jasper formation.—The one species of brachiopod (*Onychoplecia matutina* Cooper) known from the Everton-Jasper does not permit a good correlation. However, the position below the St. Peter and the presence of *Onychoplecia* is a possible link with the Lenoir of the Appalachians.

Plattin formation.—This formation in the Yellville Quadrangle ranges from

a feather edge to 100 feet in thickness. It is mostly dense blue-gray limestone often resembling lithographic limestone. The few brachiopods listed are:

Ancistrohyncha costata Ulrich and Cooper
Camerella aff. *C. panderi* Billings
Rafinesquina aff. *R. alternata* (Emmons)

Strophomena cf. *incurvata* (Shepard)
Zygospira aff. *Z. recurvirostris* (Hall)

This is a short list, but the presence of *Rafinesquina* aff. *R. alternata* suggests that part of this formation should be correlated with the Decorah-Barnhart rather than all with the Plattin. It may be noted that in the Missouri occurrences of Plattin true *Rafinesquina* is unknown, but this genus is abundant in the overlying Barnhart. In the Batesville region *Ancistrohyncha* is common and is a good indicator of the lower Plattin.

8. THE ARBUCKLE AND WICHITA MOUNTAINS, OKLAHOMA

The rocks of the Arbuckle and Wichita Mountain areas include an important section of early Middle Ordovician strata known as the Simpson group. This group consists of five formations, all of them originally proposed in charts or correlation tables. The history of the nomenclature of the Simpson group is discussed fully by Loeblich (1942, pp. 413-416) and need not be repeated here. Detailed description of the formations was published by Decker and Merritt (1931) and later elaborated by Decker (1941). As is usual with many formations in the United States, stratigraphic information may be had in minute detail, but the paleontology has never been well done. So it is with the Simpson group. The only paleontology besides Loeblich's (1942) description of the Bryozoa of the upper Simpson is the faunal listing attempted by Decker (in Decker and Merritt) in 1931. These lists are most unsatisfactory because they contain numerous identifications of genera and species now known not to occur anywhere in the Simpson sequence. In at least one instance Richmond species have been identified in a formation that cannot be younger than the Porterfield stage.

At present, and on the basis of Decker's work (1941), five formations are recognized in the Simpson group. Ulrich (1933) distinguished eight formations, but three of them were not accepted by Decker. It seems best to follow Decker in this matter at the present time, but it is possible that the future may see further splitting within the group. The five formations recognized are, from the base up: Joins, Oil Creek, McLish, Tulip Creek, and Bromide. Herein the Bromide is divided into two members. Faunal affinities of the formations are with the Appalachians and with the Great Basin. Like their geographic situation between the Appalachian and Great Basin areas, the faunas also indicate intermediate relationships to both realms.

Joins formation.—This formation consists of thin limestones and shales varying from 30 to 296 feet in thickness. It is limited to the middle southern and western parts of the Arbuckles and the north end of the Criner Hills. The formation abounds in the brachiopod *Desmorthis nevadensis*, which was formerly referred to *Orthis costalis* Hall by earlier workers. *Desmorthis costata* Cooper is

a rare species. The Oklahoma specimens, however, do not seem to be related to the New York species. *Anomalorthis* sp. occurs in the Joins also. This genus thus indicates relationship to the Oil Creek formation which occurs just above the Joins.

The occurrence of these two brachiopods in the Joins formation as well as in the overlying Oil Creek formation is interesting in connection with other fossils found in the Joins. The graptolite *Didymograptus artus* has been taken from a shaly zone and indicates relationship to the *D. bifidus* zone which occurs at the top of the Lower Ordovician (Canadian). On the basis of this graptolite, Decker assigns the Joins to the high Canadian. Such an assignment leads to difficulties, however, when the Joins is compared to the Pogonip sequence in Nevada.

The brachiopod *Desmorthis* characterizes certain beds in the Pogonip which immediately overlie the *Palliseria* [*Mitrospira*] and *Receptaculites* zones several hundred feet in thickness. These zones are not represented in the Arbuckle sequence, consequently a disconformity of considerable magnitude occurs in that area. These zones in Nevada contain fossils of post-Canadian aspects which suggest that the Joins, despite *Didymograptus artus*, should be assigned to the early Middle Ordovician.

Oil Creek formation.—This formation consists of sandstones, limestones, and shales. The sandstones are more than 200 feet thick in the eastern part of the mountains but thin to the west; the limestones thicken in the opposite direction from 20 feet to more than 500 feet. Several species of brachiopods occur in the Oil Creek which have been incorrectly assigned to species from the Chazy group. Two of them were referred to *Clitambonites*: *C. multicosta* and *C. porcia*. The former is *Anomalorthis oklahomensis* Ulrich and Cooper, but the latter is not yet redescribed. The other Chazy species identified are *Orthis acutiplicata* and *O. ignicula*. The former is described herein as *Orthambonites dinorthoides*, new species, and the other as *O. subconvexus*, new species. This formation is correlated satisfactorily with the upper Pogonip, the part which contains *Pseudomera nevadensis*, because this trilobite also occurs in the Oil Creek formation. *Lingulella* sp. 2 is another Oil Creek brachiopod.

McLish formation.—This formation consists of limestone, sandstone, and shale which reach a thickness of nearly 500 feet. Decker's list of brachiopods includes a number of obvious misidentifications:

Camarotoechia sp. = *Ancistrorhyncha* ? *perplexa* Cooper

Dorytreta bella Cooper

Glyptorthis sp. 4

Orthambonites minutus Cooper

**Orthis acutiplicata* (Identification doubtful)

O. ignicula

**Plectambonites pisum*

Ptychopleurella oklahomensis Cooper

**Rafinesquina champlainensis*

Sphenotreta sulcata Cooper

**Strophomena incurvata*

Valcourea strophomenoides ?

Zygospira recurvirostris = *Dorytreta bella* Cooper

This list includes Black River-Trenton species and some Chazy species. This formation is correlated with the Lenoir of the Southern Appalachians and shares a number of species, aside from brachiopods, with it.

Tulip Creek formation.—This formation is best known in the western part of the mountains and the Criner Hills. It consists chiefly of sandstone and shale with minor amounts of limestone. The thickness varies between 190 and 380 feet. Not many brachiopods have been found in the formation. Decker reports: *Dalmanella* sp., *Dinorthis deflecta*, and *Pionodema* sp. Neither the first nor the last genus has yet been seen in the Simpson group. The middle species is obviously misidentified because that species is restricted to the Platteville formation which is considerably younger than the Tulip Creek. The following brachiopods were taken from this formation:

Atelelasma sulcatum Cooper
Hesperorthis matutina Cooper
Mimella sp. 2
Murinella sp. 2

Orthambonites minus Cooper
Plectorthis punctata Cooper
Valcourea deckeri Cooper
V. tenuis Cooper

Correlation of Tulip Creek formation.—Abundance and kind of *Valcourea* suggest possible correlation with the Elway formation of Virginia and Tennessee.

Bromide formation.—This is the uppermost and most widespread of the Simpson formations. As at present constituted, it consists of sandstone, shale, and limestone, the latter predominating at least in the upper part. The formation is thickest at the west end of the Arbuckle Mountains where it measures 674 feet. The Bromide is divisible into two members: A lower shaly member here called the Mountain Lake member of the Bromide formation, and a limy member here called the Pooleville member.

Mountain Lake member of Bromide formation.—This name is suggested for the fine sequence of lower Bromide nearly completely exposed along Spring Creek on both sides of the line between secs. 8 and 17, T. 2 S., R. 1 W., Murray County. The name is taken from Mountain Lake, E½ sec. 22, T. 2, S., R. 1 W., near Woodford, Okla., where the shores of the lake exhibit this shale. The lower 194 feet above the basal sandstone of the Bromide consists chiefly of shales with some thin limestone beds. Between 25 and 46 feet above the sandstone the brachiopod *Sowerbyites* is abundant in association with numerous massive bryozoans. Above this zone *Valcourea transversa* is abundant. At the top of the sequence and just under the light-colored nodular limestones of the Pooleville member numerous brachiopods are associated with the cystids *Platycystites* and *Cheirocrinus*. The uppermost beds contain the brachiopod *Multicostella convexa* Cooper. This brachiopod zone affords a means of comparison with other sections and gives a clue to the facies changes.

To the east, this member appears to become more limy and in places has developed bryozoan bioherms and calcarenite banks. Along Oklahoma Highway 99, about 3 miles south of Fittstown, a fine sequence contains the *Valcourea transversa* zone. Here it occurs just above a thick calcarenite or lime sand. In the section 1.8 miles south of Sulphur, along Oklahoma Highway 18, the *Sower-*

byites zone appears in the form of a bryozoan reef on the west side of the road. The brown and purplish shales on the east side of the road contain the fauna accompanying *Multicostella convexa* at the type section.

At Rock Crossing in the Criner Hills the *Multicostella convexa* zone occurs just under the thin-bedded, light-colored limestones of the upper Bromide. The section underlying the *Multicostella* zone here is composed mostly of green shales and thin-bedded, brownish limestone.

Brachiopods from the Mountain Lake member are:

| | |
|--|---|
| <i>Acanthocrania erecta</i> Cooper | <i>Multicostella convexa</i> Cooper |
| <i>A. subquadrata</i> Cooper | <i>M. sulcata</i> Cooper |
| <i>Atelelasma oklahomense</i> Cooper | <i>Murinella partita</i> Cooper |
| <i>Bellimurina compressa</i> Cooper | <i>Onychoplecia tenuis</i> Cooper |
| <i>B. subquadrata</i> Cooper | <i>Opikina expatiata</i> Cooper |
| <i>Chaulistomella crassa</i> Cooper | <i>Ö. gregaria</i> Cooper |
| <i>C. mira</i> Cooper | <i>Oxoplecia filosa</i> Cooper |
| <i>C. mundula</i> Cooper | <i>Paurorthis macrodeltoidea</i> Cooper |
| <i>C. nitens</i> Cooper | <i>Petrocrania</i> sp. 3 |
| <i>C. obesa</i> Cooper | <i>Philhedra</i> sp. 1 |
| <i>Dactylogonia sculpturata</i> Cooper | <i>Protozyga costata</i> Cooper |
| <i>D. subaequicostellata</i> Cooper | <i>P. elongata</i> Cooper |
| <i>Doleroides compressus</i> Cooper | <i>P. magnicostata</i> Cooper |
| <i>Fascifera dalmanelloidea</i> Cooper | <i>Rostricellula cuneata</i> Cooper |
| <i>Glyptorthis crenulata</i> Cooper | <i>Skenidioides oklahomensis</i> Cooper |
| <i>G. obesa</i> Cooper | <i>Sowerbyella indistincta</i> Cooper |
| <i>G. uncinata</i> Cooper | <i>S. plicatifera</i> Cooper |
| <i>Hesperorthis crinerensis</i> Cooper | <i>S. vulgata</i> Cooper |
| <i>Lingulella galba</i> Cooper | <i>Sowerbyella</i> sp. 1 |
| <i>Macrocoelia bella</i> Cooper | <i>Sowerbyites lamellosus</i> Cooper |
| <i>Mimella extensa</i> Cooper | <i>Valcourea transversa</i> Cooper |
| <i>M. subquadrata</i> Cooper | |

Pooleville member of Bromide formation.—This name is proposed for the upper limy beds which are quite uniform in lithology from place to place but vary considerably in thickness. The name is taken from Pooleville on the west side of the Arbuckle Mountains, but the type section is on Spring Creek above the Mountain Lake member about on the line between secs. 8 and 17, T. 2 S., R. 1 W., Murray County. Here is mostly a light-gray to nearly white limestone, thin bedded except for the top 15 feet which is massive and contains *Receptaculites*. The member at the type section is about 250 feet thick. The lowest zone is that of *Strophomena oklahomensis*, then follows a zone of *Oxoplecia gouldi*, a zone of *Doleroides oklahomensis*. A zone with *Ancistrorhyncha* occurs near the top. These zones are not present in all sections, and their thicknesses are different in different sections. It is also clear from the variations of thickness in this part of the column and the different zones that occur at the top of the section in different places that the contact with the overlying Viola formation is an unconformable one.

This is essentially the interval to which Ulrich applied the name Criner on several of his charts. Ulrich, however, failed to define the formation and to designate a type section. It seems best, therefore, to use another name. Besides, the

section on Spring Creek is a more complete and far superior one in every respect to that in the Criner Hills.

Brachiopods are abundant and exquisitely preserved in most of the localities of the Pooleville member. Decker's list (Decker and Merritt, 1931, p. 48) is almost wholly from the Pooleville member and is duplicated below with corrections and additions by the writer:

Acanthocrania oklahomensis Cooper

A. subquadrata Cooper

Ancistrorhyncha costata Ulrich and Cooper

A. globularis Cooper

Camarella volborthi = *Camerella anteroplicata* Cooper

C. oklahomensis Cooper

Cliftonia gouldi = *Oxoplectia gouldi* Ulrich and Cooper

Crania granulosa = Either or both of the species of *Acanthocrania* above

C. trentonensis = *Petrocrania inflata* Cooper

Craniops tenuis Cooper

Cyclospira parva Cooper

Dalmanella fertilis = ?

Dinorthis deflecta = ? *Chaulistomella magna* Schuchert and Cooper

D. subquadrata = *Chaulistomella magna* Schuchert and Cooper

Ectenoglossa ? *sculpta* Cooper

Glossella liumbona Cooper

Hebertella bellarugosa = *Glyptorthis costellata* Cooper

H. frankfortensis = ?

**Lingula coburgensis*

L. cf. elegantula

L. eva

Lingulasma oklahomense Cooper

Lingulella ? *glypta* Cooper

Neostrophia gregaria Cooper

Onychoplectia tenuis Cooper

Öpikina extensa Cooper

O. formosa Cooper

Öpikina sp. 2

Orbiculoidea cf. lamellosa = *O. eximia* Cooper

Orthis tricenaria = *Hesperorthis sulcata* Cooper

Pachyglossa biconvexa Cooper

Paurorthis macrodeltoidea Cooper

Pionodema cf. subaequata = *Doleroides oklahomensis* Cooper

Plaesiomys sp. = ?

Platymena ? *bellatula* Cooper

Plectambonites sericeus

Plectambonites sp. (small) = ?

Plectoglossa oklahomensis Cooper

Plectorthis symmetrica Cooper

Pseudolingula imperfecta Cooper

**Rafinesquina alternata* (incorrect identification, genus not seen by writer)

Rafinesquina minnesotensis = *Öpikina*

**R. winchesterensis* = ? This is a Trenton species from Kentucky misidentified.

Rhynchotrema minnesotense = *Rostricellula transversa* Cooper

Rostricellula sp. 1

Scenidium anthonense = *Skenidioides perfectus* Cooper

Schizambon dodgei = *S. perspinosum* Cooper

Sowerbyella variabilis Cooper

Sowerbyites hami Cooper

S. lamellosus Cooper

Strophomena incurvata = *S. costellata* Cooper

S. oklahomensis Cooper

S. cf. planumbona = *S. crinerensis* Cooper

**S. trentonensis*

Zygospira nicolleti = *Protozyga loeblichii* Cooper

Correlation of Bromide formation.—The Bromide has been variously placed from the Chazyan to the Trenton (Loeblich, 1942, p. 413-416). Decker's (1952) final pronouncement was correlation with the lower Trenton. Loeblich (1942, p. 417) states that "The evidence presented by the bryozoa suggests a lower Trenton age, and the fauna is closely allied to the Decorah of Minnesota." The brachiopod evidence does not support this conclusion. This is, however, not the first instance in which age determination of the same formation based on different types of fossils is not in agreement. In considering the age of the Bromide from the brachiopod evidence, it is desirable to evaluate the brachiopods from the two divisions of the Bromide described above.

The brachiopods occurring in the lower Mountain Lake member with its reefy beds include *Atelelasma*, *Multicostella*, *Mimella*, *Sowerbyites*, and *Valcourea*. These are genera that occur together in the Appalachian sequences in formations underlying the Benbolt formation. They are common particularly in the Lincolnshire and Hogskin formations. The presence of *Fascifera* and *Öpikina* suggest somewhat higher beds because the former has not been taken in the two Appalachian formations referred to below the Ward Cove. Conspicuously absent from the lower part of the Mountain Lake member is *Strophomena*, which becomes abundant in the Appalachians in beds above the Benbolt formation, particularly in the Wardell formation. The best correlation of the lower Mountain Lake is with the Lincolnshire.

Upper Mountain Lake abounds in cystids, *Platycystites* and *Cheirocrinus*, with abundance of *Sowerbyella*, *Chaulistomella*, and *Glyptorthis*. Also present are *Fascifera* and *Doleroides*. Correlation with the Benbolt is suggested.

Significant brachiopods occurring in the upper or light-colored Pooleville member are: *Strophomena*, *Doleroides*, *Craniops*, *Campylorthis*, and *Ancistro-rhyncha*. These genera characterize beds in the Appalachians and the Central Basin that overlie the Benbolt. The association, except for *Craniops*, appears first in the Wardell formation of the Appalachians and in the Ridley limestone of the Central Basin of Tennessee. The correlations thus suggested indicate that Bromide sediments spanned a time similar to the sediments of the Appalachians between, but including the Lincolnshire and the Wardell.

Viola formation.—Information on this formation is now relevant to the discussion of brachiopods forming the subject of this monograph because of Decker's (1952) recent correlations of the Athens shale of Virginia with part of the Viola limestone of Oklahoma. The report of *Nemagraptus* in the Viola is quite dis-

turbing because it leads to a correlation that is in distinct conflict with that indicated by other groups of animals.

The Viola limestone is commonly a light-gray to dark-buff limestone, but it may be nearly white with scattered brown blotches. The limestone is usually tough, fine-grained, but some coarsely crystalline beds occur in it. At Rock Crossing in the Criner Hills a shaly zone occurs at the base, but a similar shaly zone occurs elsewhere 100 to 150 feet above the base. The limestone is mostly thin bedded in layers 2 to 6 inches thick. The formation, minus the Upper Ordovician (Fernvale), attains a thickness of 165 to 880 feet.

The Viola formation has been dated as spanning the time of Trenton to Richmond sedimentation. The Upper Ordovician has been separated as the Fernvale formation. The only part of the Viola of immediate concern in this discussion is the lower part and that of the shales. Brachiopods reported from the lower member of the Viola according to Decker (1933, p. 1414) are:

**Dalmanella hamburgensis*
Dinorthis pectinella
Paterula polita Cooper
Platystrophia sp.
**Plectambonites sericeus*

**Rafinesquina deltoidea*
**Rhynchotrema increbescens*
**Strophomena filitexta*
**Zygospira recurvirostris*

Examination of this list will at once disclose that some of the names are probably incorrect. The combination of species does not exist anywhere else and seems impossible from what is known of Trenton faunas elsewhere. The list, however, is sufficiently accurate to show that the assemblage belongs above the lower Trenton. The presence of *Dinorthis pectinella* suggests the Ion member of the Decorah formation, but the reported presence of *Platystrophia* makes further complications. This genus does not appear below the Trenton as far as present knowledge goes. Furthermore, it is not known in low Trenton but characterizes Hull in New York and Ontario and the Prosser in the upper Mississippi Valley.

On the basis of brachiopods, therefore, the lower Viola would be placed at the lowest with about middle Trenton. Decker (1952, p. 100) makes the same age assignment for the Viola. Inconsistent with this age, however, is Decker's (1952, p. 101) reported discovery of the *Nemagraptus* fauna in the lower part of the Viola. The occurrence of the trilobite *Robergia* in the Viola and its presence in the "Athens" (Liberty Hall) led Decker to correlate these two divisions of rock. It might be suggested here that an inconsistency exists with the trilobite and perhaps also with the graptolite. In the Appalachians the *Nemagraptus* fauna is the midgraptolite zone of the Athens at the Athens type locality, as in other parts of the Appalachians. It has been shown above that type Athens is equivalent to the Arline formation. In Catawba Valley the *Nemagraptus* fauna occurs 300 feet above Botetourt-Effna formations which are equivalent to part of the Arline. Now the Arline fauna is many hundreds of feet below the Oranda or overlying Salona faunas, which are the only ones in the Appalachian Valley that could be correlated with the lower Viola brachiopods listed above. Thus *Nemagraptus* in the Appalachians is definitely below Oranda-Salona faunas. However, the

Oranda is undoubtedly a derivative of the Arline whose black shale equivalent, if any existed, might conceivably have included a *Nemagraptus* derivative in the higher position. Possibly this is the case with *Nemagraptus* in the Viola—it is a holdover or recurrent *Nemagraptus* fauna equivalent to a middle Trenton brachiopod fauna. If this supposition should prove to be true, our views regarding the infallibility of graptolite correlation will be severely shaken.

Womble (Stringtown) formation of Arkansas and Oklahoma.—A thick sequence of dark shales occurs in the Ouachita geosyncline in Arkansas and adjacent Oklahoma. This is the Womble (Stringtown in Oklahoma) shale which contains the *Nemagraptus* graptolite assemblage and is said (Decker 1952, pp. 96-100) to be equivalent to the "Athens" of Virginia. Two brachiopods, *Archaeorthis biconvexa* Cooper, new species, and *Paterula subcircularis* Cooper, were taken from this shale in Oklahoma.

9. THE BLACK HILLS, SOUTH DAKOTA

Whitewood formation.—This formation as exposed just northeast of Deadwood, S. Dak., consists of three members. The lowest member overlies the *Scolithus* sandstone of the Upper Cambrian Deadwood formation and consists of gray fissile shale containing scolecodonts and a few other fragmentary fossils. Above the shale occurs a coarse-grained, soft, light-gray siltstone which contains conodonts and remains of other types of fossils. The siltstone is transitional to the overlying dolomite member of the Whitewood formation which contains fossils of probable upper Devonian age.

The shale and siltstone members are said by Furnish, Barragy, and Miller (1936) to be of medial Ordovician age. The scolecodont fauna of the shale indicates a correlation with the Spechts Ferry member of the Decorah formation. The siltstone contains the following brachiopods:

Crania ?

Dalmanella ? cf. *D. hamburgensis* (Winchell, not Walcott) = *Dalmanella winchelli* Cooper

Lingula sp.

Rafinesquina sp.

Rhynchotrema cf. *R. minnesotense* (Sardeson)

Sowerbyella sp.

Strophomena sp.

Zygospira

This list of brachiopods and species of conodonts indicates a low Trenton (Rockland) age for the siltstone.

10. THE GREAT BASIN—NEVADA AND CALIFORNIA

The Ordovician of the Great Basin region in Nevada and California has never been described in detail, and actually very little is known about it. In some areas rocks comprising the Pogonip group or formation have been assigned to the Chazy and some to the Black River and Trenton, but the faunas are nearly unknown. After two short visits to southern and central Nevada the writer is able

to give a brief statement on the major divisions of the early Middle Ordovician in the Antelope Valley west of Eureka, Nev., and in the range fronting Frenchman Flat about 45 miles northwest of Las Vegas, Nev. Although I have seen and collected from all the rocks mentioned herein, I am indebted to Drs. Edwin Kirk and C. W. Merriam, of the U. S. Geological Survey, for information as to localities and for the use of their collections.

ANTELOPE VALLEY AND TOQUIMA RANGE

Between the top of the Canadian and the base of the Upper Ordovician, in the region between Eureka and the Antelope Valley, occurs a remarkable thickening of the sequence to the west. Examination of both sides of Antelope Valley and the east side of the Toquima Range, 25 miles west of the Antelope Range, is necessary to build a composite section. Even after this is done the complete section has never been ascertained, and some uncertainty exists as to sequence.

In ascending order the following divisions were recognized:

POGONIP GROUP: With *Orthidiella* zone, *Pallaseria* (formerly *Mitrospira*) zone, *Desmorthis* zone, *Anomalorthis* zone, *Rhysostrophia* zone; **EUREKA GROUP:** With a lower 25-foot sandstone, yellow limestone with *Sowerbyites*, dark shale with *Reuschella*, and upper or Eureka quartzite. All the zones below the lower sandstone have hitherto been placed in the Upper Pogonip limestone, a term that has for many years outlived its usefulness.

POGONIP GROUP: Orthidiella zone.—Lowest zone of the sequence characterized by the small brachiopod *Orthidiella*. Specimens abundant, often silicified. In Whiterock Canyon, Roberts Mountains Quadrangle, the limestone of the zone rests on green shale thought to be the same as that at the top of the Canadian. The *Orthidiella* zone is better developed and replete with fossils in the first ridge east of Frenchman Flat on the Las Vegas, Nev., Quadrangle. Here 150 feet of heavy-bedded limestone underlies the *Palliseria* (*Mitrospira*) beds. Most of the brachiopods listed below were taken from the Frenchman Flat locality, but many of them were seen also in Whiterock Canyon.

Idiostrophia nuda Cooper

Ingria claudi Ulrich and Cooper

Liricamera nevadensis Cooper

Orthambonites eucharis (Ulrich and Cooper)

Orthidiella carinata Ulrich and Cooper

O. costellata Cooper

O. extensa Ulrich and Cooper

O. longwelli Ulrich and Cooper

Orthidiella sp. 1

Porambonites sp. 3

Trematorthis masoni Ulrich and Cooper

T. robusta Cooper

T. tenuis Cooper

Correlation.—At present few of the genera listed above have been certainly identified in any North American deposits other than those of Nevada. Brachiopods suggesting *Orthidiella* occur in the Table Head series of Newfoundland. *Trematorthis lévisensis* Ulrich and Cooper is known from the limestone No. 2 boulder bed of the Lévis shale. This suggests a younger age for this bed than hitherto suspected.

Pallaseria (Mitrospira) zone.—Consists of a great thickness of heavy-bedded limestone abounding in the snail that gives the zone its name, and also

in large *Maclurites* which are suggestive of those of the Chazy group of the Champlain Valley, N. Y. The upper part of the zone is characterized by abundance of *Receptaculites*. No brachiopods have been described from this zone.

Rhysostrophia sp. 1

Desmorthis zone.—This zone overlies the *Receptaculites* beds of the *Pal-laseria* (*Mitrospira*) zone. The bed is well displayed under the Eureka quartzite on the west and south sides of Lone Mountain about 18 miles west-northwest of Eureka, Nev. It consists of dark, moderately heavy-bedded limestone containing *Desmorthis nevadensis* Ulrich and Cooper in abundance and often exquisitely silicified. In addition, *Anomalorthis nevadensis* Ulrich and Cooper and *A. lonensis* (Walcott) occur. *Hesperonomiella minor* (Walcott) is a less well known species.

Correlation.—Abundant *Desmorthis* and *Anomalorthis* signify correlation of this part of the "Pogonip" with the Joins formation of Oklahoma.

Anomalorthis zone.—Under this heading are placed thin-bedded limestones abounding in sponges described by Bassler (1941), abundant *Pseudomera* and other peculiar trilobites, together with *Anomalorthis* and a few other brachiopods, as follows:

Aporthophyla typa Ulrich and Cooper

Orthambonites minusculus (Phleger)

Idiostrophia paucicostata Cooper

Porambonites sp. 1

Lingulella sp. 1

Correlation.—Presence of the trilobite *Pseudomera* and the brachiopod *Anomalorthis* indicate correlation with the Oil Creek formation of Oklahoma.

Rhysostrophia zone.—Consists of thin-bedded limestone abounding in fossils. Some of the brachiopods are silicified, while others occur in a silicious matrix which permits dissolving the shell away from the rock to produce impressions of the interior. The following species are known:

Goniotrema perplexum Ulrich and Cooper

Rhysostrophia nevadensis Ulrich and Cooper

Hesperomera leptellinoidea Cooper

R. occidentalis Ulrich and Cooper

Leptellina occidentalis Ulrich and Cooper

Sowerbyella rugosa Ulrich and Cooper

Orthambonites bifurcatus Cooper

Syndielasma biseptatum Cooper

O. occidentalis Cooper

Taphrodonta parallela Cooper

O. paucicostatus (Ulrich and Cooper)

Toquimia kirki Ulrich and Cooper

Orthidium bellulum Ulrich and Cooper

Valcourea intracarinata Ulrich and Cooper

Porambonites ? *umbonatus* Cooper

Correlation.—This is a difficult fauna to place, but it has obvious affinities with the Table Head Series of Newfoundland and some of the boulders of the Mystic conglomerate. *Rhysostrophia* occurs in both of the formations named and so does *Orthidium*. The latter genus also links these beds to the limestone No. 2 of Lévis, Quebec. The Newfoundland faunas are still too little known to make any close comparisons. Another genus common to the Table Head and *Rhysostrophia* zone is *Porambonites*.

EUREKA GROUP: Lower 25-foot sandstone.—On Martins Ridge, west side of Antelope Valley, northeast of the Martin Ranch, the Pogonip is overlain by

a 25-foot bed of brown sandstone containing a few cephalopods. This bed is thought by some (Kirk, 1933) to be the lower part of the Eureka sandstone. In Lone Mountain, 18 miles north-northwest of Eureka, the main body of the White Eureka sandstone is thought to rest on the "lower sandstone," but in Martins Ridge some 350 feet of limestone and shale intervene between the two sandstones.

Yellow limestone.—Overlying the "lower sandstone" occurs about 150 feet of thin-bedded, yellow-weathering limestone abounding in fossils. Generally the specimens are not well preserved, and they are not silicified. One of the abundant genera is *Sowerbyites*. The species identified from this bed are:

Camerella umbonata Cooper

Camerella sp. 3

Eoplectodonta alternata (Butts)

Isophragma ponderosum Cooper

Lingulasma occidentale Cooper

Macrocoelia occidentalis Cooper

Multicostella parallela Cooper

M. rectangulata Cooper

Oxoplectia monitorenensis Cooper

Sowerbyella sp. 4

Sowerbyites lamellosus Cooper

Valcourea plana Cooper

Correlation.—The brachiopods listed suggest a correlation with the Arline formation of the Southern Appalachians. The relationship is best shown by the presence of *Isophragma*, which has not been seen outside of this horizon and the lower part of the Benbolt formation. The presence of *Sowerbyites* is not an anomaly because that genus ranges from the Lincolnshire to the level of the Bromide (approximately Ridley-Wardell). The *Macrocoelia* is also in accord with the suggested correlation. The zone in question cannot be lower than Lincolnshire or higher than Benbolt, with the balance in favor of the Arline-Effna level.

Dark shale with *Reuschella*.—Overlying the yellow-weathering limestone are dark shales, about 150 feet in thickness, abounding in brachiopods and other fossils reminding one most strongly of the Oranda formation of Virginia. Here occur:

Bilobia hemispherica Cooper

Bimuria sp. 1

Cristiferina cristifera Cooper

Eoplectodonta alternata (Butts)

Glyptorthis sp. 1

Hesperorthis antelopensis Cooper

Leptaena ordovicica Cooper

Leptellina incompta Cooper

Oxoplectia nevadensis Cooper

Paurorthis gigantea Cooper

Plectorthis obesa Cooper

Reuschella vespertina Cooper

Rostricellula angulata Cooper

Sowerbyella merriami Cooper

Sowerbyella sp. 1 and 2

Strophomena sp. 1

Correlation.—The *Reuschella*, *Bilobia*, *Leptaena*, and *Eoplectodonta* are links to the Oranda formation. This is corroborated by the presence of the trilobite *Cryptolithus*. The other genera are all more or less common in the Virginia formation.

Eureka quartzite.—The main mass of the Eureka, sparkling quartzite, white and heavy-bedded, overlies the dark shales. It underlies the Hanson Creek formation of probable Maquoketa age. This fixes the level of the Eureka as probably middle or high Trenton.

PIOCHE DISTRICT, NEVADA

The Tank Hill formation is named from Tank Hill in the Ely Springs Range west of Pioche, Nev. The formation also appears at the north end of the Bristol Range. It consists of 450 feet of gray thin-bedded limestone, conglomeratic in the lower part. The upper 50 feet is shaly limestone with abundant fossils. Brachiopods are:

Hesperinia kirki Cooper
Orthambonites sp.

CALIFORNIA

Phleger (1933, p. 2) proposed the Mazourka and Barrell Spring formations for Ordovician rocks exposed in the Inyo Range, east-central California.

Mazourka formation.—This formation consists of argillaceous shales and limestones 675 feet thick. Fossils are not well preserved, but several brachiopods were collected and some new species described, as follows:

Crania sp.
Orthis minusculus Phleger = *Orthambonites minusculus* (Phleger)
Plectorthis mazourkaensis Phleger
P. patula (Phleger)
Triplexia sp. = syntrophoid

Besides the brachiopods listed, interesting trilobites were collected indicating correlation of these beds with the Oil Creek of Oklahoma and the *Anomalorthis* zone of the Pogonip. These trilobites are *Pseudomera barrandei* (Billings), *Encrinurus hastula* Phleger, and *E. octonarius* Phleger, the latter two being referable to the genus *Ectenonotus* which occurs in the East in the Table Head series and Mystic boulders.

Barrel Spring formation.—This formation was also proposed by Phleger (1933, p. 5) for 130 feet of quartzites, impure limestones, and argillaceous shales. Three brachiopods are listed:

**Orthis tricenaria* Conrad = *Hesperorthis* ?
O. decipiens Phleger = *Hesperorthis* ? *decipiens* (Phleger)
Plectambonites angulatus Phleger = *Valcourea angulata* (Phleger)

The identification of *Orthis tricenaria* Conrad is almost certainly a mistake, but the identification may indicate some other species of *Hesperorthis*. Although the description of *Plectambonites angulatus* states that the "Pedicel valve [is] evenly convex, but gently arched along the median line from beak to front," the figure of the one cotype illustrated gives the impression that the specimen is really nearly flat or gently concave. Furthermore, the long slits representing the pits formed by the dental plates in the impression and the muscle scars suggest *Valcourea* rather than *Plectambonites*. The latter name is undoubtedly used in the old sense and would now be called *Sowerbyella*, inasmuch as true *Plectambonites* is at present unknown on this continent.

The lithology and the few fossils known from the Barrel Spring formation

suggest correlation with the lower yellow beds overlying the 25-foot quartzite in Martins Ridge on the east side of the Monitor Range.

II. FORMATIONS IN UTAH

Pogonip equivalents of post-Canadian age occur in Utah where sections and brachiopods have been described.

IBEX AREA, UTAH

Hintze (1951) has split the Pogonip of western Utah, Millard County, into six formations in ascending order: House limestone, Fillmore limestone, Wahwah limestone, Juab limestone, Kanosh shale, and Lehman formation. The formations below the Wahwah limestone have few brachiopods, but the top of the formation is characterized by a bed 1 foot thick abounding in *Hesperonomiella minor* (Walcott). The Juab limestone contains *Orthambonites subalatus* (Ulrich and Cooper). The Kanosh shale is characterized by *Orthambonites michaelis* (Clark) and *Anomalorthis utahensis* Ulrich and Cooper. *Kirkina millardensis* Salmon is reported from the top of the Kanosh shale and the overlying Lehman formation. The Kanosh shale thus seems to be the equivalent of the Oil Creek of Oklahoma and the *Anomalorthis* zone in Nevada. These names do not appear on the chart.

NORTHEASTERN UTAH

Swan Peak quartzite.—This formation contains the brachiopods *Orthambonites subalatus* (Ulrich and Cooper), *O. michaelis* (Clark), *O. swanensis* (Ulrich and Cooper), *Anomalorthis utahensis* Ulrich and Cooper, *A. lonensis* (Walcott), *Syntrophopsis utahensis* Ulrich and Cooper, and *Westonia ? elongata* Walcott. The presence of *Anomalorthis* suggests correlation with the Oil Creek of Oklahoma and the *Anomalorthis* zone in Nevada.



SECTION II. THE FOSSILS

GENERAL DISCUSSION OF THE FOSSILS

After the appearance of the publication on Ozarkian and Canadian Brachiopoda, to which the present monograph is a sequel, brachiopod studies were considerably retarded by World War II. Nevertheless, some important ideas have been expressed. One of these has to do with the naming of the valves of brachiopods. Hitherto the valves have been known as ventral and dorsal, but the work of Percival (1944) makes mandatory a return to the more cumbersome terms "pedicle" and "brachial,"¹ which are used throughout this monograph.

CONCEPT OF FAMILY AND GENUS

The same principles that guided Ulrich and Cooper in the preparation of the Ozarkian and Canadian Brachiopoda are used in the present monograph. The basis for uniting genera into families is again basically the pattern of the cardinalia combined with some constant features of the pedicle valve. Genera are then based on minor details of the interior deviating from the normal family pattern and the nature of the ornamentation and exterior form of the valves. Specific characters are found in minor details of the ornamentation and differences in exterior form.

SHELL STRUCTURE

The writer has used shell structure as a guide in classification, but it is far too early to propose the nature of the shell as a basis of classification. Too much has to be learned about shell structure before it will have real value in defining major divisions. The arrangement of convenience used in the Shimer-Shrock "North American Index Fossils" (1944) has been misconstrued by some as a scheme of classification. It was not so proposed; the arrangement was designed to help the student separate brachiopods into easily recognized small groups in order to make identification easier.

In the present work the shells are again divided for convenience into groups based on shell structure. In the endopunctate shells the genera and families are probably well grouped, but with the impunctate and pseudopunctate forms some difficulties are still to be mastered. For example, the orthoid genus *Anomalorthis* appears to have scattered pseudopunctae; it is also well known through the work of Öpik (1934) on the clitambonitids that some of these genera are pseudopunctate while others are without pseudopunctae. These difficulties cannot be resolved in this monograph because much of the material does not permit detailed

¹ In a recent note Percival discards his views of 1944 and indicates that the orientation of *Terebratella inconspicua* agrees with that of *Tegulorhynchia* and the pedicle valve is ventral in orientation.

knowledge of the shell structure, and furthermore the problem is one that concerns all the brachiopods and not just those of the early Middle Ordovician.

NOTES ON EVOLUTION

The time in which the brachiopods here described lived is not a long one geologically speaking, yet considerable change took place in brachiopod evolution. During this time the appearance and rise of several major groups, as far as now known, took place, namely, the dalmanellids, rhynchonellids, and spiriferoids. In addition this time saw the heyday of the plectambonitids. Among the *Gastrocaulia*, Cambrian types still lingered on, but the group as a whole had already lost ground to the *Pygocaulia* except in a few limited habitats.

Gastrocaulia.—Perhaps the most interesting feature connected with the inarticulate brachiopods is the persistence into the Middle Ordovician of genera that definitely have Cambrian affinities. This is strikingly seen in the genus *Dictyonites* which is structurally a member of the Dictyoninacea, new superfamily, a specialized group of early brachiopods. This group at present defies classification in either Neotremata or Atremata, because there is no pedicle foramen, nor is there a pedicle groove as in the linguloids.

The appearance of *Lingula* in the Ordovician has been stated as a fact, yet the writer does not use that name for any of the linguloids described herein. The etched linguloids from Pratt Ferry make it clear that, on hinge structures at least, the linguloids of the part of the Ordovician covered by this monograph are varied and some of them have the definite characters of *Lingulella*. It cannot now be said that *Lingula* did not exist in the Middle Ordovician, but the specimens that could be prepared, and the apical structures revealed, all proved to have other affinities. For this reason the name *Lingulella* was preferred to *Lingula* for species whose apical structures could not be revealed.

The limestone of the Pratt Ferry formation in particular and bituminous limestones associated with black shales in general yielded many specimens of the conical Acrotretacea. These showed more variety than has hitherto been revealed in the Middle Ordovician. The genus *Conotreta* is obviously related to the Cambrian shells now called *Homotreta* and others like them, but the Ordovician genera seem to have more elaborate pallial markings than those from the Cambrian. The bizarre interior of *Ephippelasma* is still not understood, but it is here suggested that the saddle-shaped plate of the brachial valve is probably a lophophore support.

Lingulasma is a giant form of linguloid characterized by elevated muscle platforms. The genus seems to be totally unrelated to the Trimerellidae but may have affinities with *Lingulops*.

The early trimerellid genus *Obolellina* is characterized by the modest development of the muscle platforms which become highly elevated in the Silurian members of the superfamily.

The genus *Schizambon* is of interest because it is a spiny genus that appeared in the earliest Ordovician and persisted into late Middle Ordovician. The mem-

bers of this genus available for study have been examined with great care, but no basis was found for generic separation anywhere along the line.

The Craniidae appear in this part of the Ordovician well formed except for two possible genera and proved to be fairly common in places. The cemented habit seems to have been well established. *Eocomulus* is a small cone that is abundant in the suite of formations at the base of the rocks deposited in the Porterfield stage. Only brachial valves that have a primitive musculature are known. These are not postulated as the forerunners of the Craniacea because *Acanthocrania*, a more standard genus, occurs with them.

A form of uncertain relationships, *Undiferina*, possibly was a cementing brachiopod. The median septum and general form of the one known valve suggest relationship to *Conotreta* and allies rather than to the Craniacea. It is possible that the Acrotretacea may have developed a cemented form, but this is not yet positively known.

The insoluble residues from the Pratt Ferry limestone yielded a number of forms of which single valves only are known. Perhaps the most peculiar among these is the brachiopod here called *Trematis* ? *spinosa*, which at present is known only from the brachial valve. This valve contains a tuft of spines on the hinge area. The purpose of these spines cannot at present even be conjectured. Spines such as these on the opposite valve might have been used for attachment in early stages as they are in the Productacea, but attachment spines on a brachial valve are at present unknown. The Pratt Ferry residues have opened the door only a slight crack but have permitted a fleeting glance at the form and habits of a wonderful world of inarticulate brachiopods. Much of significance and interest to morphology and classification is yet to come from these shells that have been thought to be retarded in evolution and diversification.

Pygocaulia.—This monograph contains many new articulate genera that have been revealed by extensive collecting and also by the acid treatment of limestones. The Pratt Ferry limestone has produced some of the most unusual forms. The Effna-Rich Valley limestone, Botetourt formation, and Arline formation, all belonging to a related suite of beds which are likewise related to the Pratt Ferry formation, have yielded other odd genera. The result is that some families have become unexpectedly large and much has been learned about hitherto poorly known brachiopods.

The Table Head series and upper Pogonip group have yielded their share of unclassifiable material. These formations form a sort of bridge between the Lower Ordovician (Canadian) rocks and those laid down in the Marmor stage. They have produced brachiopods that are intermediate in their structure between the Canadian ones and the higher genera. An example is *Syndielasma* which is prophetic of *Sowerbyella* but differs in not having the cardinalia welded together as in the later genera. *Hesperomena* is a more primitive leptellinoid than the higher ones as it does not have the visceral disk elevated. The Table Head brachiopod fauna gives indications of containing numerous genera that will plug gaps in the developmental stages of the families of the Middle Ordovician brachiopods when it is fully studied.

ORTHIDAE.—The members of this family are fairly abundant but show few remarkable features. It is interesting to note that many of the species have strong resemblances to European forms. One of the interesting European types is *Productorthis* which is represented by two species, both of which, as true American representatives, far outstrip in size any of the known European species. The American species are not exactly like the European ones, especially in the cardinal process, but the exterior is similar.

HESPERORTHIDAE.—This family is represented by numerous species of the genus *Hesperorthis* and, in places, hosts of *Glyptorthis*.

DINORTHIDAE.—This family had its probable origin and culmination in the time spanned by this monograph. The earliest genera are *Valcourea* and *Multicostella*. The latter, which lacks a pseudodeltidium, is probably the more advanced form. The last of the American multicostellate Dinorthidae except *Plaesiomys* appear in the Lebanon and Carters formations. There they are strongly convex-concave and without a pseudodeltidium. The origin of the family is uncertain, but it may have been derived from *Hesperonomia* as suggested by Ulrich and Cooper (1938, p. 20).

PLECTORTHIDAE.—The earliest member of this family appears as *Desmorthis* in the Joins and Pogonip formations of the Whiterock stage. The genus is short ranged but may have developed into *Plectorthis* in the time represented by Tulip Creek sedimentation. *Plectorthis* has a long range into the Upper Ordovician. In general the older species of *Plectorthis* are more finely ribbed than those of the higher formations and the Upper Ordovician. *Mimella* is an abundant Marmor form which extends into the Dryden and Wardell but then gives way to *Doleroides* which is the probable forerunner of *Hebertella*. No origination stock for the Plectorthids can now be postulated other than the Finkelnburgiidae as indicated by Ulrich and Cooper (1938, p. 18).

SKENIDIIDAE.—This group appears in the formations deposited in Marmor time, and some of its members are fairly long ranged. *Skenidioides* appears in Porterfield time and extends into the Silurian. In this family, too, are placed a smooth to plicate form of skenidioid which has modified cardinalia, *Tropidothyris*. *Scaphorthis* and *Phragmorthis* are also placed within the family. These are characterized by cruralia and the latter by an enormous median septum. *Scaphorthis* has the profile and ornamentation suggesting a dalmanelloid, but the shell is definitely impunctate. Origin of these shells is obscure indeed, and they may not be a natural group as now placed.

TRITOECHIIDAE.—This family is represented by the unusual genus *Eremotoechia* that is essentially a strongly biconvex *Tritoechia* having the external appearance of *Mimella*. In spite of appearances the genus has the apically perforated pseudodeltidium (the foramen is smaller than in *Tritoechia*) and cardinalia of the Ordovician (Canadian) genus. The few specimens in the collection do not show development of a pseudospondylium such as that often exhibited by *Tritoechia*. No other shells related to this one were seen, and this may be the end of the stock.

CLITAMBONITIDAE.—This family is represented by *Atelelasma* which is spe-

cialized to the extent that it has lost the pseudodeltidium. The stock is an ancient one, first appearing in rocks laid down in Marmor time, and extends into the late Porterfield stage.

KULLERVOIDAE.—This family is represented by a few specimens only of the genus *Kullervo*. Pseudopunctae, which are a family character, were not seen in the American shells.

CAMERELLIDAE.—After the Whiterock stage, members of the Syntrophiacea are rare or absent, but the Camerellidae take their place and are often very abundant. The group reaches its zenith in the rocks deposited from Whiterock to Wilderness time. After that time the group declines. Certain trends may be detected in some genera. *Plectocamara* is especially noteworthy for the reduction of the median septum of the brachial valve. *Brevicamera*, which forms a family by itself, is noteworthy because of its sessile cruralium, the only genus to achieve such a structure. The variety of exteriors and shapes exhibited by members of the Camerellidae may ultimately permit further separation of genera. The camerellids are structurally like syntrophids and probably arose from them, but the change from a spondylium simplex in the latter group to a spondylium duplex of the Camerellidae cannot be explained.

PARALLELELASMATIDAE.—This family belongs to the Pentameracea and is characterized by having two long, subparallel septa in the brachial valve which enclose the muscle scars. The family is represented by three genera unlike in appearance but close internally. *Parallelelasma* occurs in the Pratt Ferry formation and is the earliest known pentamerid. Although it is an early form, it is nevertheless a very complicated shell in its articulation at both ends of the valves. The webbed costae at the front are a novel strainer device. The source of this unusual group was not detected in the early Middle Ordovician; it must be sought in Whiterock or earlier faunas.

RHYNCHONELLACEA.—One of the important events that took place in the time spanned by this monograph is the arrival of the rhynchonellids. These appear in the form of *Rostricellula* and *Ancistrorhyncha*. The former is the earlier, but it is the more complicated shell of the two. *Rostricellula* has the standard rhynchonellid complement of a cruralium (or septalium), hinge plate, and strong median septum in the brachial valve, and dental plates in the pedicle valve. *Ancistrorhyncha*, on the other hand, has complicated crura, a divided hinge plate, but no median septum. This is probably an advanced form which cannot be ancestral to the rhynchonellids. The same is true of *Rostricellula* which is an early but specialized type. The ancestor of the group must be looked for in rocks deposited in Whiterock time or earlier. Several small shells, such as *Oligorhynchia*, *Dorytreta*, and *Sphenotreta*, appear to be rhynchonellids. These are probably primitive forms in that they have a fold on the pedicle valve, which is an early character. They are, however, specialized forms, too, in their complicated ornamentation, especially *Oligorhynchia*.

ATRYPACEA and SPIRIFERACEA.—The advent of the calcified lophophore, as far as now known, took place within the time embraced by this monograph. The shells are all small and are generally rare in the earlier formations. The first

spire bearer is a small undescribed form from the Row Park formation of Maryland and a probably contemporaneous one, possibly the same species, from the Crown Point formation of New York. Only single specimens are known in each instance; consequently, the interior is not known. Both of these are *Protozyga*-like shells. This seems to be the most primitive of the genera. The spire has only one volution. This genus, however, is fairly long ranged and becomes fairly large in the late members of the genus in the Trenton group. No originating form can now be postulated.

Idiospira and *Cyclospira* have more complicated spires. The former suggests affinities with *Atrypa* and allies in which the spire is coiled toward the brachial valve. In the latter the spiral coils are directed inward. *Cyclospira* and *Zygospira* may have arisen from *Protozyga*. The same origin is possible for *Idiospira*.

PLECTAMBONITACEA.—The present study shows the members of this superfamily to be numerous, extensively distributed, and diverse in structure. In North America the first of these appear in rocks deposited during late Canadian time, and a fairly large development took place in Whiterock time and culminated in the Porterfield stage. Three major stocks can be recognized: The palaeostrophomenoids, probably originated from *Aporthophyla*, the leptellinoids, and the sowerbyelloids; the origin of the last two is obscure. The first group is well represented in Europe as well as America. The group also is commonest in rocks deposited during Porterfield time. Distinctive genera are *Apatomorpha*, *Palaeostrophomena*, *Glyptambonites*, and *Sowerbyites*, which have similar growth forms to the Strophomenidae. These genera are characterized by having a single septum in the brachial valve. The sowerbyelloids have two or more septa and form a prolific group that appears in the Whiterock stage and continues on into the Silurian. This group may have come from *Syndielasma* or some still more primitive pseudopunctate shell such as *Pelonomia*. The leptellinoids are characterized by a visceral disk and strong median septum. They appear in the late Canadian with *Leptella* and become moderately common in the early part of the Middle Ordovician. They continue into the Silurian but are generally rare fossils at that time. It is not possible to say what the derivation of the Plectambonitids is, but the most likely ultimate origin is from an orthid stock sometime in the early Ordovician or late Cambrian. *Cymbithyris* Cooper (1952), a concavo-convex billingsellid of the late Cambrian, is a possibility.

STROPHOMENIDAE.—It has been shown that the resupinate and normally convex forms of this division are closely related. The resupination of the shells seems not to be a valid means of classification (A. Williams, 1953). The genera of this subfamily probably originated in some orthoid stock in the early Ordovician, possibly from some form like *Taffia* or *Aporthophyla*. *Kirkina* is the oldest known form in this group having a lobate cardinal process. At any rate it appears in the Marmor stage as *Macrocoelia* and rapidly becomes more diverse. Species of *Strophomena* and *Öpikina* are the commonest shells in certain parts of the country in rocks deposited during the Wilderness stage.

LEPTAENIDAE.—This division seems to have originated with *Hesperinia* in the high Pogonip, deposited during the Whiterock stage. At any rate this genus has

a bilobed cardinal process necessary to produce the leptaenoids. The family retained its pedicle opening through all the time embraced by this monograph.

DALMANELLACEA.—The earliest known punctate brachiopod on this continent is *Paurorthis*, which is found in rocks formed during the Ashby stage. The genus has some features that relate it to the Orthidae, such as the form of the vascula media and the nature of the brachiophores. It seems difficult, however, to derive other punctate forms from this one.

Several other punctate stocks appear simultaneously in the Porterfield stage: *Cyclomyonia*, *Paucicrura*, and *Laticrura*. The first-named has the structure of *Pionodema* and the Schizophoriidae. It seems to form a satisfactory originating point for that family, but the stock from which *Cyclomyonia* itself came cannot be conjectured. *Paucicrura* may have been derived from *Paurorthis*. This seems possible, but it cannot be accepted with assurance. With *Paucicrura* came the large family of Onniellidae which has a greater development in Europe than in America. *Laticrura* parallels *Scaphorthis* in its cardinalia, and no progenitor is known for it. The Heterorthidae appear to have had their origin outside of America, possibly in the Llandeilo of Great Britain. *Elasmothyris* appears to be a complicated punctate brachiopod but is probably out of the main line.

ANNOTATED LIST OF GENERA AND SPECIES

| GENERA | | | | | |
|-------------------------|----------------------------|------------------------------|--|---|-----|
| Column on chart | Stratigraphic distribution | Geographic distribution | Remarks | Page | |
| Genus | | | | | |
| <i>Acanthambonia</i> | 35 | Porterfield | Ala., Va. | Confined to Porterfield stage | 211 |
| <i>Acanthocrania</i> | 32 | Porterfield to Mississippian | North America | Fairly common in Ordovician rocks | 283 |
| <i>Acrotreta</i> | 19 | Whiterock | Quebec, Newfoundland | Type known from Estonia | 245 |
| <i>Ancistrorhynchia</i> | 6 | Marmor to Wilderness | Appalachians, N. Y., Midwest, Mingan Islands | Usually confined to calcutite | 618 |
| <i>Anisopleurella</i> | 42 | Porterfield | Ala., Tenn., Va., Scotland | Occurs in British Isles | 804 |
| <i>Anomalorthis</i> | 31 | Whiterock | Okla., Nev., Utah | Only known from western U. S. | 391 |
| <i>Apatomorpha</i> | 44 | Porterfield | Tenn. | Confined to basal Athens near Athens | 709 |
| <i>Aporthophylla</i> | 32 | Whiterock | Nev., Newfoundland | Possible early progenitor of Strophomenacea | 698 |
| <i>Archaeorthis</i> | .. | Canadian to Porterfield? | Quebec, British Columbia, Great Basin, Tex., Okla. | Appears also in Table Head | 293 |
| <i>Atelelasma</i> | 24 | Marmor to Porterfield | Appalachians, N. Y., Vt., Okla. | European affinities uncertain | 517 |
| <i>Bellimurina</i> | 25 | Porterfield to Wilderness | Appalachians, Minn., Okla. | Not confined to Trenton rocks | 854 |
| <i>Bilobia</i> | 18 | Porterfield to Wilderness | Appalachians, Great Basin, Scotland, Europe | Present in Girvan, Scotland | 759 |
| <i>Binuria</i> | 26 | Porterfield to Wilderness | Appalachians, Great Basin, Scotland | Present in Girvan, Scotland | 764 |
| <i>Brevicanera</i> | 44 | Porterfield | Ala. | Rare and unknown elsewhere | 560 |
| <i>Camerella</i> | 8 | Canadian to Richmond | Appalachians, Great Basin, Newfoundland, Quebec, British Isles | Present in the Girvan region, Scotland | 562 |
| <i>Campylorthis</i> | 25 | Wilderness | Mississippi Valley | Not yet known outside Mississippi Valley | 429 |
| <i>Chaulistomella</i> | 28 | Porterfield to Wilderness | Appalachians, Tenn., Okla. | Characteristic of Appalachians | 432 |

| | | | | | |
|----------------------|----|-----------------------------|---|--|-----|
| <i>Chonetoides</i> | .. | Porterfield to Wilderness | Va. | Present in British Isles and Norway | 804 |
| <i>Christiania</i> | 29 | Porterfield to Richmond | Appalachians, Vt., Newfoundland, Quebec, British Isles, Europe, Alaska | Worldwide in Northern Hemisphere | 859 |
| <i>Colaptonema</i> | 35 | Trenton | Va. | A homeomorphic development toward <i>Leptostrophia</i> | 889 |
| <i>Conotreta</i> | 30 | Porterfield to Trenton | Appalachians, N. Y., British Isles | Present in Girvan, Scotland; possibly same as <i>Acrotreta</i> | 247 |
| <i>Craniops</i> | 5 | Wilderness to Mississippian | Appalachians, British Isles, Mississippi Valley | Present in Girvan, Scotland | 240 |
| <i>Craspedelia</i> | 39 | Porterfield | Ala. | Known only from Pratt Ferry | 772 |
| <i>Cristiferina</i> | 30 | Porterfield to Wilderness | Great Basin, Appalachians | Not yet recognized outside North America | 961 |
| <i>Cyclomyonia</i> | 35 | Porterfield | Ala. | Pratt Ferry only | 974 |
| <i>Cyclospira</i> | 18 | Porterfield? to Richmond | Appalachians, N. Y., E. Canada, Mississippi Valley, British Isles | Present in Girvan, Scotland | 693 |
| <i>Cyphomena</i> | 27 | Porterfield to Trenton | Appalachians, Quebec | Known only from Appalachians with certainty | 840 |
| <i>Cyrtontotella</i> | 25 | Ashby to Porterfield | Appalachians, Europe, British Isles | Present in Girvan, Scotland | 318 |
| <i>Dactylogonia</i> | 22 | Marmor to Porterfield | Appalachians, N. Y., Vt., Mingan Islands | Confined to Appalachian realm | 824 |
| <i>Dalmanella</i> | 19 | Wilderness to Silurian | Appalachians, W. Tenn., Mississippi Valley, N. Y., Canada, British Isles | Uppermost limit not yet known | 948 |
| <i>Desmorthis</i> | 30 | Whiterock | Okla., Nev. | Only known from western U. S. | 446 |
| <i>Dictyonites</i> | 36 | Porterfield | Ala. | A Cambrian type | 187 |
| <i>Didymelasma</i> | 20 | Wilderness | W. Tenn., Ontario | Rare | 615 |
| <i>Dinorthis</i> | 16 | Ashby to Trenton | Appalachians, W. Tenn., Mississippi Valley, Europe, Canada, British Isles | Present in Girvan, Scotland | 393 |
| <i>Diorthelasma</i> | 34 | Porterfield | Ala. | Earliest of the Schizophorinae | 997 |

ANNOTATED LIST OF GENERA AND SPECIES—Continued

GENERA

| Genus | Column on chart | Stratigraphic distribution | Geographic distribution | Remarks | Page |
|------------------------|-----------------|----------------------------|--|---|------|
| <i>Doleroides</i> | 14 | Porterfield to Wilderness | Appalachians, N. Y., Canada, Mississippi Valley | Confined to facies of western belts in Appalachians | 456 |
| <i>Dorytreia</i> | 26 | Marmor-Ashby | Tenn., Okla. | Belongs to Appalachian realm | 666 |
| <i>Drepanorhynchia</i> | 8 | Wilderness to Trenton | N. Y., Ontario | Rare | 627 |
| <i>Ectenglossa</i> | 5 | Whiterock-Wilderness | Newfoundland, Appalachians, Canada | Confined to black shale and limestone facies | 217 |
| <i>Eichwaldia</i> | 32 | Wilderness | Canada, British Isles | A rare genus | 947 |
| <i>Elasmothyrus</i> | 45 | Porterfield | Ala. | Confined to Pratt Ferry | 983 |
| <i>Elliptoglossa</i> | 4 | Canadian to Richmond | Canada, Appalachians, Mississippi Valley | Abundant in black shale and limestone facies | 241 |
| <i>Eoconulus</i> | 34 | Porterfield | Ala., Va. | Large, undescribed species in Botetourt | 282 |
| <i>Eopectodonta</i> | 3 | Porterfield to Silurian | Appalachians, British Isles, Norway, Nev. | Present in Girvan, Scotland | 807 |
| <i>Ephippelasma</i> | 37 | Porterfield | Ala. | Confined to Pratt Ferry | 261 |
| <i>Eremotoechia</i> | 23 | Porterfield | Southern Appalachians | Youngest of the Tritoechiidae | 513 |
| <i>Eremotrema</i> | 20 | Porterfield | Va. | Not yet known elsewhere | 959 |
| <i>Eridorthis</i> | .. | Porterfield to Eden | Appalachians, Ky., Ontario | Known in Appalachians only from Porterfield | 383 |
| <i>Fascifera</i> | 17 | Porterfield to Wilderness | Southern Appalachians, Okla. | Mostly in shale and calcilitite facies | 998 |
| <i>Furcitella</i> | 33 | Wilderness to Trenton | Appalachians, Upper Mississippi Valley, W. Tenn. | Rare in Appalachians | 875 |
| <i>Glossella</i> | 3 | Porterfield to Wilderness | Ala., Okla. | So far found only in limestone facies | 228 |
| <i>Glyptambonites</i> | 3 | Porterfield to Wilderness | Southern Appalachians | Found in reef rock and dirty sandstone | 712 |
| <i>Glyptoglossa</i> | 37 | Porterfield | Md., Pa. | Rare | 226 |
| <i>Glyptomena</i> | 23 | Marmor to Porterfield | Appalachians, N. Y., Vt., Mingan Islands | Chiefly in limestone environment | 881 |

| <i>Glyptorthis</i> | 13 | Marmor to Silurian | Appalachians, Canada, Great Basin, Mississippi Valley, British Isles | Abundant with many species still to be described | 361 |
|-----------------------|----|------------------------------|--|--|-----|
| <i>Goniotrema</i> | .. | Whiterock | Nev. | Rare | 711 |
| <i>Hallina</i> | 23 | Wilderness | Appalachians, Mississippi Valley | Mostly found in calcilitite | 689 |
| <i>Hesperinia</i> | 20 | Whiterock | Nev. | Rare | 822 |
| <i>Hesperomena</i> | 34 | Whiterock | Nev. | Rare | 744 |
| <i>Hesperonomella</i> | 35 | Whiterock | Great Basin, Quebec | Abundant in western U. S. | 337 |
| <i>Hesperorthis</i> | 9 | Marmor to Richmond | Appalachians, Midwest, Great Basin, Canada | Rare in European faunas | 343 |
| <i>Idiospira</i> | 34 | Wilderness to Trenton | Mississippi Valley, Canada, Ky., N. J. | Mostly found in calcilitite | 690 |
| <i>Idiostrophia</i> | 14 | Whiterock | Nev., East Canada, Newfoundland | Usually a rare fossil | 587 |
| <i>Ingria</i> | 24 | Whiterock | Nev., Estonia | Abundant in southern Nevada | 700 |
| <i>Isophragna</i> | 32 | Porterfield | Southern Appalachians, British Isles, Nev. | Present in Girvan, Scotland, fauna | 733 |
| <i>Kirina</i> | .. | Whiterock | Nev. | Rare | 866 |
| <i>Kullervo</i> | 45 | Porterfield | Southern Appalachians, Europe, British Isles | Represented by small species | 527 |
| <i>Laticrura</i> | 5 | Porterfield-Wilderness | Appalachians, British Isles | Present in Girvan, Scotland | 979 |
| <i>Leptaena</i> | 17 | Porterfield to Mississippian | Worldwide | Earliest known in basal Edinburg | 820 |
| <i>Leptellina</i> | 17 | Whiterock to Wilderness | Appalachians, N. Y., Vt., Great Basin | Probably present in Europe | 747 |
| <i>Leptobolus</i> | .. | Porterfield? to Richmond | N. Y., Appalachians?, Mississippi Valley | Not certainly known in Appalachians | 213 |
| <i>Limbimurina</i> | 4 | Porterfield to Wilderness | Va., Pa. | Found mostly in bedded or massive calcarenite | 851 |
| <i>Lingulasma</i> | 3 | Ashby? to Wilderness | Appalachians, Mississippi Valley Great Basin, British Isles | Usually crushed | 232 |
| <i>Lingulella</i> | .. | Cambrian to Wilderness? | North America, British Isles, Europe | Probably frequent in the Ordovician | 195 |
| <i>Liricamera</i> | 12 | Whiterock | Nev. | An aberrant camerellid | 592 |

ANNOTATED LIST OF GENERA AND SPECIES—Continued

| Genus | Column on chart | GENERA | | | Page |
|----------------------|-----------------------|-------------------------------|--|--|------|
| | | Stratigraphic distribution | Geographic distribution | Remarks | |
| <i>Macrocoelia</i> | 21 | Marmor to Porterfield | Appalachians, Great Basin, Mingan Islands | Widespread in North America | 890 |
| <i>Microtrypa</i> | 16 | Wilderness | Ontario | | |
| <i>Minella</i> | 11 | Marmor to Wilderness | Appalachians, E. Canada, Mis- sissippi Valley, W. Tenn., Okla. | Not yet identified in U. S. but certainly will be found | 878 |
| <i>Mullicostella</i> | 12 | Marmor to Wilderness? | Appalachians, N. Y., Vt., E. Canada, Okla., Great Basin, British Isles | Not yet known in Europe | 468 |
| <i>Murimella</i> | 8 | Ashby to Wilderness | Appalachians, Okla. | Present in Girvan, Scotland | 416 |
| <i>Neostrophia</i> | .. | Whiterock to Wilderness? | Okla., Quebec, British Colum- bia | Confined to Appalachian realm | 844 |
| <i>Nicolella</i> | .. | Wilderness to Trenton | N. Y., Va., Pa., British Isles | Rare | 590 |
| <i>Nothorthis</i> | 46 | Canadian to Porterfield | Quebec, Vt., Ala. | More common in European faunas | 316 |
| <i>Obolellina</i> | 21 | Wilderness to Trenton | Ontario, upper Mississippi Val- ley | Lévis occurrence may = Whiterock | 315 |
| <i>Obolus</i> | .. | Cambrian? to Porterfield? | North America, British Isles, Europe | Rare | 230 |
| <i>Oligorhynchia</i> | 15 | Ashby to Wilderness | Southern Appalachians | Mostly in the dark shales in North America | 189 |
| <i>Omniella</i> | 24 | Wilderness to Richmond | North America, British Isles, Europe | Possibly present in the Girvan, Scotland, fauna | 658 |
| <i>Onychoplecia</i> | 1 | Whiterock to Porterfield | N. Y., Vt., Mingan Islands, Ark., Newfoundland, Appala- chians | Upper limit not yet established | 953 |
| | | | | Earliest of the triplesids | 529 |

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|--------------------------|----|---------------------------|--|--|-----|
| <i>Öpikina</i> | 13 | Ashby to Richmond | Appalachians, N. Y., E. Canada, Midwest | Uncommon in most European faunas | 903 |
| <i>Orbiculoida</i> | 12 | Wilderness? to Permian? | North America, Europe | Rare in early rocks | 275 |
| <i>Orthambonites</i> | 16 | Canadian to Trenton? | Great Basin, Appalachians, N. Y., E. Canada, British Isles, Europe | Common mostly in the earlier rocks | 294 |
| <i>Orthidiella</i> | 28 | Whiterock | Great Basin | Common in southern Nevada | 338 |
| <i>Orthidium</i> | 23 | Whiterock | Great Basin, E. Canada, Newfoundland | Lévis occurrence suggested to be Whiterock | 340 |
| <i>Oxoplecta</i> | 28 | Ashby to Middle Silurian | Appalachians, Great Basin, upper Mississippi Valley, Canada, Europe | Present in Girvan, Scotland | 539 |
| <i>Pachyglossa</i> | 5 | Porterfield to Wilderness | Appalachians, Okla., Mississippi Valley | Probably widespread | 223 |
| <i>Palaeoglossa</i> | .. | Whiterock to Wilderness? | Quebec, N. Y., Appalachians | Rare | 221 |
| <i>Palaeostrophomena</i> | 28 | Porterfield | Southern Appalachians, British Isles, Europe | Present in Girvan, Scotland | 700 |
| <i>Parallelelasma</i> | 36 | Porterfield | Ala. | The earliest of the Pentameridae | 611 |
| <i>Parastrophina</i> | 17 | Porterfield to Trenton | Appalachians, Champlain Valley, Mississippi Valley, Ontario, British Isles | Present in Girvan, Scotland | 604 |
| <i>Paterula</i> | 22 | Canadian to Trenton | E. Canada, Newfoundland, Appalachians, Okla., British Isles, Europe | Belongs to black shale and limestone facies | 236 |
| <i>Paucicostella</i> | 33 | Whiterock | Newfoundland | A rare fossil | 711 |
| <i>Paucicrura</i> | 18 | Porterfield to Richmond? | North America, Europe, British Isles | Upper limit not yet known | 956 |
| <i>Paurorthis</i> | 9 | Ashby to Trenton | Great Basin, Okla., S. Appalachians, British Isles, Europe | Present in Girvan, Scotland | 964 |
| <i>Pelononia</i> | 11 | Whiterock | Newfoundland | Possible progenitor of plectambonitids | 699 |
| <i>Perimecocoelia</i> | 38 | Porterfield | Southern Appalachians | Exterior a convergence toward <i>Parastrophina</i> | 593 |

ANNOTATED LIST OF GENERA AND SPECIES—Continued

GENERA

| Genus | Column on chart | Stratigraphic distribution | Geographic distribution | Remarks | Page |
|----------------------|-----------------------|---------------------------------|--|--|------|
| <i>Petrocrania</i> | 32 | Marmor to Permian? | Worldwide | Earliest forms large and with cementing-habit developed | 287 |
| <i>Petroria</i> | 36 | Probably Canadian | British Columbia | Early form related <i>Leptella</i> | 746 |
| <i>Philhedra</i> | 4 | Porterfield to Mississippian | Worldwide | Upper range not certain | 291 |
| <i>Phragmorthis</i> | 37 | Porterfield to Trenton | Southern Appalachians, British Isles? | The Devonian <i>Mystrophora</i> is a convergence | 508 |
| <i>Pionodema</i> | 7 | Porterfield? to Middle Silurian | Quebec, Ontario, Mississippi Valley, W. Tenn., Appalachians | Rare in European faunas and usually referred to other genera | 986 |
| <i>Pionomena</i> | 8 | Ashby to Wilderness | Appalachians | Found in the calcilitites | 901 |
| <i>Platymena</i> | 14 | Porterfield-Wilderness? | Appalachians, Okla. | Rare | 879 |
| <i>Plectocamara</i> | 16 | Ashby to Wilderness | Appalachians | An end member of the camerellid line | 596 |
| <i>Plectoglossa</i> | 2 | Porterfield to Wilderness | Appalachians, Okla. | Rare | 222 |
| <i>Plectorthis</i> | 7 | Ashby to Cincinnati | Appalachians, Great Basin, Mississippi Valley, Canada, Okla. | Not certainly known in Europe but widely identified | 447 |
| <i>Pleurothis</i> | 18 | Whiterock | Quebec, Newfoundland | An aberrant stock | 329 |
| <i>Porambonites</i> | .. | Whiterock? to Richmond | Great Basin, Newfoundland, Pa., British Isles, Europe | Whiterock occurrences probably new genus | 609 |
| <i>Productorthis</i> | 41 | Porterfield | Appalachians, Europe | Usually larger and more robust than European species | 333 |
| <i>Protorhynchia</i> | .. | Marmor | N. Y. | A genus of uncertain status | 618 |
| <i>Protozyga</i> | 14 | Ashby to Trenton | N. Y., Appalachians, Mississippi Valley | Widespread and abundant in calcilitites | 674 |
| <i>Pseudobolus</i> | 15 | Ashby to Porterfield | Va. | Rare | 194 |
| <i>Pseudolingula</i> | .. | Marmor? to Richmond | E. Canada, Ky., Appalachians, Midwest | Uncertain | 215 |
| <i>Ptychoglyptus</i> | 33 | Whiterock? to Porterfield | Appalachians, Quebec, Newfoundland | Not certainly identified in Europe | 815 |

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|------------------------|----|-----------------------------------|--|---|-----|
| <i>Ptychopleurella</i> | 29 | Marmor to Helderberg | Appalachians, N. Y., Quebec, British Isles | Side branch from <i>Glyptorthis</i> | 385 |
| <i>Rafinesquina</i> | 31 | Wilderness to Richmond? | North America, Europe, British Isles, Asia | Evidently originated in late Wilderness time | 886 |
| <i>Reuschella</i> | 17 | Wilderness to Trenton | Vt., Va., Great Basin, British Isles | More common in Europe | 976 |
| <i>Rhipidomena</i> | 20 | Ashby to Porterfield | Southern Appalachians | Confined to Appalachians | 866 |
| <i>Rhynchotrema</i> | 28 | Trenton | N. Y., Ky., Canada, Mississippi Valley, Appalachians, Nev. | A descendant of <i>Rostricellula</i> | 628 |
| <i>Rhysostrophia</i> | 29 | Whiterock | Quebec, Nev., Newfoundland | Characteristic of the White- rock stage | 559 |
| <i>Rhyssotrema</i> | 33 | Porterfield | Ala. | Confined to Pratt Ferry | 258 |
| <i>Rostricellula</i> | 10 | Marmor to Trenton | Appalachians, N. Y., Nev., E. Canada, Mississippi Valley, British Isles | Present in Girvan, Scotland | 630 |
| <i>Salonia</i> | 11 | Trenton | Pa. | Rare | 615 |
| <i>Scaphelasma</i> | 38 | Porterfield | Ala. | Confined to Pratt Ferry | 259 |
| <i>Scaphorthis</i> | 30 | Porterfield | Southern Appalachians | Probably present in British Isles | 502 |
| <i>Schizambon</i> | 10 | Canadian to Trenton | Great Basin, E. Canada, N. Y., Mingan Islands, Appalachians, British Isles, Europe | Present in Girvan, Scotland | 264 |
| <i>Schizocrania</i> | 36 | Wilderness to Trenton | Mississippi Valley, E. Canada, N. Y., Appalachians, British Isles | Rare in early Middle Ordo- vician | 275 |
| <i>Schizotreta</i> | 4 | Ashby to Wilderness | Appalachians, N. Y., British Isles, Europe | Present in Girvan, Scotland | 277 |
| <i>Siphonotreta</i> | .. | Canadian to Porterfield | Tenn., British Isles, Europe | Rare | 263 |
| <i>Skenidioides</i> | 7 | Porterfield to Middle Silurian | Appalachians, W. Tenn., Missis- sippi Valley, Okla., British Isles | Abundant in many lithologies | 491 |
| <i>Sowerbyella</i> | 15 | Whiterock to Richmond | North America, British Isles, Europe | Abundant after Marmor time | 774 |
| <i>Sowerbyites</i> | 31 | Ashby to Trenton? | Great Basin, Quebec, Appa- lachians, Europe, Greenland | Not yet seen in British Isles | 723 |

ANNOTATED LIST OF GENERA AND SPECIES—Continued

| GENERA | | | | Page |
|-----------------------|-----------------|--------------------------------|---|------|
| Genus | Column on chart | Stratigraphic distribution | Geographic distribution | |
| <i>Sphenotreta</i> | 2 | Marmor to Porterfield | Appalachians, N. Y., Okla. | 663 |
| <i>Spinlingula</i> | 39 | Porterfield | Ala. | 210 |
| <i>Spondylotreta</i> | 43 | Porterfield | Ala., Va. | 255 |
| <i>Stenocamara</i> | 31 | Marmor to Ashby | Southern Appalachians | 602 |
| <i>Strophomena</i> | 30 | Porterfield to Richmond | North America, British Isles, Asia | 926 |
| <i>Syndiclasma</i> | 25 | Whiterock | Nev. | 742 |
| <i>Taphrodonta</i> | 26 | Whiterock | Nev. | 740 |
| <i>Taphrothis</i> | 43 | Porterfield | Southern Appalachians | 326 |
| <i>Teratlasma</i> | 23 | Porterfield | East Tenn. | 823 |
| <i>Titanambonites</i> | 27 | Marmor to Porterfield | Southern Appalachians | 717 |
| <i>Toquima</i> | 27 | Whiterock | Nev. | 698 |
| <i>Torynelasma</i> | 40 | Porterfield | Ala. | 257 |
| <i>Trematis</i> | 5 | Porterfield to Cincinnati | E. Canada, Appalachians, Mississippi Valley | 270 |
| <i>Trematorthis</i> | 13 | Whiterock | Nev. | 341 |
| <i>Trigrammaria</i> | 19 | Wilderness | Ontario, Mississippi Valley, N. Y. | 874 |
| <i>Triplezia</i> | 28 | Porterfield to Middle Silurian | Eastern North America, British Isles, Europe | 537 |
| <i>Tropidothyris</i> | 42 | Porterfield | Ala. | 507 |
| <i>Undiferina</i> | 41 | Porterfield | Ala. | 262 |
| <i>Valcourea</i> | 19 | Marmor to Porterfield | Quebec, Me., N. Y., Vt., Okla., Appalachians, Great Basin | 404 |
| <i>Westonia</i> | 7 | Cambrian to Middle Silurian | North America | 209 |
| <i>Xenambonites</i> | 40 | Porterfield | Ala. | 813 |
| <i>Zygospira</i> | 22 | Porterfield? to Richmond | North America | 669 |
| | | | Remarks | |
| | | | Primitive rhynchonellid usually in calcarenites | |
| | | | Known from Pratt Ferry only | |
| | | | Known from Pratt Ferry and Efnia calcarenites | |
| | | | Rare, aberrant camerellid | |
| | | | Possibly a polyphyletic group | |
| | | | Rare convergence toward <i>Sowerbyella</i> | |
| | | | Rare | |
| | | | An aberrant orthid | |
| | | | Rare aberrant leptaenid | |
| | | | A European type | |
| | | | Aberrant early plectambonitid | |
| | | | Confined to Pratt Ferry | |
| | | | Rare in early Middle Ordovician | |
| | | | Rare in Nevada and Quebec | |
| | | | Probably fairly common | |
| | | | Rare before Trenton time | |
| | | | Confined to Pratt Ferry | |
| | | | Confined to Pratt Ferry | |
| | | | Aberrant dinorthis | |
| | | | Rare | |
| | | | Specialized sowerbyellid | |
| | | | Common after Porterfield time | |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|---|------------------------|---|--|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>Acanthambonia minutissima</i> Cooper | Porterfield | Pratt Ferry | Ala. | 212 |
| <i>A. virginiensis</i> Cooper | Porterfield | Botetourt? | Va. | 213 |
| <i>Acanthocrania cumberlandensis</i> (Foerste) | Wilderness | Wells | Tenn. | 284 |
| <i>A. erecta</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 284 |
| <i>A. grandis</i> Cooper | Porterfield | Benbolt | Va. | 284 |
| <i>A. granulosa</i> (N. H. Winchell) | Wilderness- Trenton | Decorah | Minn. | 285 |
| <i>A. oklahomensis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 285 |
| <i>A. setigera</i> (Hall) | Wilderness- Trenton | Platteville Decorah | Wis. and Minn. | 285 |
| <i>A. spinosa</i> Cooper | Porterfield | Edinburg (Liberty Hall) | Va. | 285 |
| <i>A. subquadrata</i> Cooper | Porterfield | Bromide (Mountain Lake) (Pooleville) | Okla. | 286 |
| <i>Acanthocrania</i> sp. 1 | Wilderness | Lebanon | Tenn. | 286 |
| <i>Acrotreta gemma</i> Billings | Whiterock | Table Head | Newfoundland | 246 |
| <i>A. magna</i> Cooper | Whiterock | Boulders of Mystic cgl. | Quebec | 246 |
| <i>Ancistrorhyncha australis</i> (Foerste) | Wilderness | Lebanon, Camp Nelson, Nealmont | Tenn., Pa. | 620 |
| <i>A. costata</i> Ulrich and Cooper | Wilderness | Dryden, Ridley, Wardell, Hostler, Bromide, Pamela, Plattin | Tenn., Va., Pa., Ark., Okla., N. Y., Mo., Ga. | 621 |
| <i>A. crassa</i> Cooper | Wilderness | Peery, Hostler, Wardell, Dryden | Tenn. | 623 |
| <i>A. globularis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 624 |
| <i>A. missouriensis</i> Cooper | Porterfield | Rock Levee | Mo. | 624 |
| <i>A. ? perplexa</i> Cooper | Marmor | McLish | Okla. | 625 |
| <i>A. ? vacua</i> Cooper | Marmor | Mingan | St. Lawrence River, Quebec | 625 |
| <i>Anisopleurella inaequistriata</i> Cooper | Porterfield | Whitesburg, Chatham Hill | Tenn., Va. | 805 |
| <i>A. tricostellata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 806 |
| <i>Anomalorthis lonensis</i> (Walcott) | Whiterock | Upper Pogonip, Swan Peak | Nev., Utah | 392 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|----------------------|--|---------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>A. nevadensis</i> Ulrich and Cooper | Whiterock | Upper Pogonip, (<i>Anomalorthis</i> zone) | Nev. | 392 |
| <i>A. oklahomensis</i> Ulrich and Cooper | Whiterock | Oil Creek | Okla. | 392 |
| <i>A. utahensis</i> Ulrich and Cooper | Whiterock | Swan Peak, Kanosh, Upper Pogonip | Utah, Nev. | 393 |
| <i>Apatomorpha pulchella</i> (Raymond) | Porterfield | Athens | Tenn. | 709 |
| <i>Archaeorthis biconvexa</i> Cooper | Porterfield | Womble | Okla. | 293 |
| <i>Ateleasma decorticatum</i> Cooper | Ashby | Murat, Lincolnshire, Whistle Creek? | Va., Tenn. | 518 |
| <i>A. dorsoconvexum</i> Cooper | Porterfield | Athens | Tenn. | 519 |
| <i>A. holstoni</i> (Hall and Clarke) | Ashby or Porterfield | Lincolnshire (Hogskin), or Arline | Tenn. | 520 |
| <i>A. ? multicostum</i> (Hudson) | Marmor | Crown Point | N. Y., Vt. | 520 |
| <i>A. obscurum</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 520 |
| <i>A. oklahomense</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 521 |
| <i>A. perfectum</i> Cooper | Porterfield | Arline, Whistle Creek? | Tenn., Va. | 522 |
| <i>A. planum</i> Cooper | Porterfield | Benbolt | Tenn. | 523 |
| <i>A. platys</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 523 |
| <i>A. sulcatum</i> Cooper | Ashby | Tulip Creek | Okla. | 524 |
| <i>A. variabile</i> Cooper | Marmor | Lenoir | Tenn. | 525 |
| <i>Atelesma</i> sp. 1 | Porterfield | Little Oak | Ala. | 526 |
| <i>Atelesma</i> sp. 2 | Porterfield | Botetourt | Va. | 526 |
| <i>Bellimurina charlottae</i> (Winchell and Schuchert) | Wilderness | Decorah (Guttenberg) | Minn. | 855 |
| <i>B. compressa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 855 |
| <i>B. concentrica</i> Cooper | Porterfield | Pierce | Tenn. | 856 |
| <i>B. parviplicifera</i> Cooper | Wilderness | Lebanon | Tenn. | 856 |
| <i>B. subquadrata</i> Cooper | Wilderness | Bromide (Mountain Lake) | Okla. | 857 |
| <i>B. sulcata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 858 |
| <i>B.</i> sp. 1 | Porterfield | Benbolt? | Va. | 858 |
| <i>B.</i> sp. 2 | Wilderness | Wardell | Va. | 859 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|---------------------------------------|---------------------------|---|---------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>Bilobia hemisphaerica</i> Cooper | Wilderness | Oranda, Rodman, dark shale of Eureka group, Salona | Va., Pa., Nev. | 760 |
| <i>B. pisum</i> (Ruedemann) | Wilderness or Porterfield | Boulder in Rysedorf cgl. | N. Y. | 762 |
| <i>B. virginiensis</i> Cooper | Porterfield | Edinburg (<i>Cyrt.-Nid.</i> zone), Shippensburg, Botetourt | Va., Md., Pa. | 762 |
| <i>Bimuria buttsi</i> Cooper | Porterfield | Little Oak | Ala. | 765 |
| <i>B. immatura</i> Cooper | Porterfield | Botetourt, Effna-Rich Valley | Va. | 766 |
| <i>B. lamellosa</i> (Bassler) | Wilderness | Oranda | Pa., Va. | 767 |
| <i>B. ? matutina</i> Cooper | Whiterock | Boulders in Mystic cgl. | Quebec | 768 |
| <i>B. parvula</i> Cooper | Porterfield | Shippensburg, Chatham Hill, Edinburg (<i>Cyrt.</i> zone), Liberty Hall | Pa., Va. | 769 |
| <i>B. siphonata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 770 |
| <i>B. superba</i> Ulrich and Cooper | Porterfield | Botetourt, Effna, Arline, Tellico | Va., Tenn. | 771 |
| <i>Bimuria</i> sp. 1 | Wilderness | Dark shale, under Eureka quartzite | Nev. | 772 |
| <i>Brevicamera camerata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 561 |
| <i>Camerella anteroplicata</i> Cooper | Porterfield | Bromide (Pooleville) | Okla. | 562 |
| <i>C. bella</i> Fenton | Wilderness | Carters, Platin (Macy) | Tenn., Mo. | 563 |
| <i>C. bicostata</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 564 |
| <i>C. breviplicata</i> Billings | Whiterock | Boulder in Mystic cgl. | Quebec | 565 |
| <i>C. costellata</i> Cooper | Ashby | Elway | Tenn., Va. | 565 |
| <i>C. edmundsoni</i> Cooper | Porterfield | Poteet (Yellow Branch) | Va. | 566 |
| <i>C. elliptica</i> Cooper | Ashby | Lincolnshire | Va. | 567 |
| <i>C. globularis</i> Cooper | Ashby | Whistle Creek | Va. | 568 |
| <i>C. gregeri</i> Cooper | Wilderness | Platin (Macy) | Mo. | 569 |
| <i>C. immatura</i> Cooper | Porterfield | Chatham Hill | Va. | 570 |
| <i>C. indefinita</i> Cooper | Ashby | Elway | Tenn. | 570 |
| <i>C. ? leiorhynchoidea</i> Cooper | Wilderness? | Edinburg (Liberty Hall) | Va. | 571 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------|---|--|------|
| <i>C. minuta</i> Cooper | Porterfield | Botetourt, Effna, Chatham Hill | Va. | 571 |
| <i>C. multiplicata</i> Cooper | Ashby | Elway | Tenn., Va. | 572 |
| <i>C. nuda</i> Cooper | Porterfield | Murfreesboro | Tenn. | 573 |
| <i>C. obesa</i> Cooper | Wilderness | Rockland | N. Y. | 574 |
| <i>C. oklahomensis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 574 |
| <i>C. parva</i> Billings | Whiterock | Table Head (N, P) | Newfoundland | 575 |
| <i>C. pennsylvanica</i> Cooper | Marmor | Row Park | Pa. | 575 |
| <i>C. perplexa</i> Cooper | Ashby | Elway | Tenn., Va. | 576 |
| <i>C. plicata</i> (Schuchert and Cooper) | Wilderness | Ridley, Wardell | Tenn. | 577 |
| <i>C. polita</i> Billings | Whiterock | Boulders in Mystic cgl. | Quebec | 578 |
| <i>C. ? primigenia</i> (Bradley) | Trenton | Kimmswick | Mo., Ark. | 578 |
| <i>C. pulchra</i> Cooper | Wilderness | Ridley | Tenn. | 578 |
| <i>C. quadriplicata</i> (Willard) | Ashby | Lincolnshire (Hogskin) | Tenn. | 579 |
| <i>C. tennesseensis</i> Cooper | Porterfield | Arline | Tenn. | 580 |
| <i>C. triangulata</i> Cooper | Marmor | Lenoir | Tenn. | 581 |
| <i>C. tumida</i> Cooper | Whiterock | Table Head | Newfoundland | 582 |
| <i>C. umbonata</i> Cooper | Ashby | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 582 |
| <i>C. unicostata</i> Cooper | Porterfield | Ward Cove | Tenn. | 583 |
| <i>C. varians</i> Billings | Marmor | Mingan, Crown Point | St. Lawrence River, Quebec, N. Y. | 583 |
| <i>C. ventricosa</i> Cooper | Marmor | Crown Point | N. Y. | 584 |
| <i>C. volborthi</i> Billings | Wilderness | Cloche Island, Rockland | Ontario, Manitoulin | 585 |
| <i>Camerella</i> sp. 1 | Porterfield | Benbolt | Tenn. | 586 |
| <i>Camerella</i> sp. 2 | Marmor | Blackford | Va. | 586 |
| <i>Camerella</i> sp. 3 | Ashby | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 586 |
| <i>Camerella</i> sp. 4 | Porterfield | Whitesburg | Tenn. | 587 |
| <i>Campylorthis deflecta</i> (Conrad) | Wilderness | Platteville (McGregor) | Wis., Minn., Ill. | 430 |
| <i>C. subplana</i> Ulrich and Cooper | Wilderness | Plattin (Macy), Barnhart | Mo. | 431 |
| <i>Chaulistomella brevis</i> (Willard) | Porterfield | Benbolt, Dryden, Sevier | Tenn., Va. | 433 |
| <i>C. crassa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 434 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|------------------------------|---|--------------------------|------|
| <i>C. elongata</i> (Willard) | Porterfield | Benbolt, Dryden | Tenn. | 435 |
| <i>C. inaequistriata</i> Cooper | Wilderness | Wardell, Dryden | Tenn., Va. | 435 |
| <i>C. lebanonensis</i> Cooper | Wilderness | Carters, Lebanon, Camp Nelson, Cane Creek | Ala., Ky., Tenn. | 437 |
| <i>C. magna</i> (Schuchert and Cooper) | Wilderness | Bromide (Pooleville) | Okla. | 438 |
| <i>C. mira</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 439 |
| <i>C. mundula</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 440 |
| <i>C. nitens</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 441 |
| <i>C. obesa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 441 |
| <i>C. rectangulata</i> Cooper | Wilderness | Wardell | Tenn. | 442 |
| <i>C. ridleyensis</i> Cooper | Wilderness | Ridley | Tenn. | 443 |
| <i>C. superlata</i> Cooper | Wilderness | Ridley | Ga. | 444 |
| <i>Chaulistomella</i> sp. 1 | Wilderness | Carters | Ala. | 445 |
| <i>Chaulistomella</i> ? sp. 2 | Wilderness | Oranda | Va. | 445 |
| <i>Chonetoidea virginica</i> Cooper | Porterfield- Wilderness | Edinburg (Liberty Hall) | Va. | 804 |
| <i>Christiania auriculata</i> Cooper | Wilderness | Oranda | Va. | 860 |
| <i>C. platys</i> Cooper | Porterfield | Edinburg (<i>Nidulites</i> and <i>Cyrtonotella</i> zones) | Va. | 861 |
| <i>C. subquadrata</i> (Hall) | Porterfield | Little Oak "Lenoir," Arline, Athens, Botetourt Effna, Edinburg (<i>Cyrt.</i> & <i>Nid.</i> zones), Pratt Ferry, Young- man, Rich Valley | Tenn., Ala., Va., Vt. | 862 |
| <i>C. trentonensis</i> Ruedemann | Porterfield or Wilderness | Rysedorf | N. Y. | 865 |
| <i>Colaptomena leptostrophoidea</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 890 |
| <i>Conotreta</i> ? <i>alta</i> Cooper | Porterfield | Arline | Tenn. | 248 |
| <i>C. ? altirostra</i> Cooper | Porterfield | Botetourt | Va. | 248 |
| <i>C. apicalis</i> Cooper | Porterfield | Pratt Ferry | Ala. | 249 |
| <i>C. ? concentrica</i> Cooper | Porterfield | Pratt Ferry | Ala. | 250 |
| <i>C. cuspidata</i> Cooper | Porterfield | Effna | Va. | 250 |
| <i>C. depressa</i> Cooper | Porterfield | Pratt Ferry | Ala. | 251 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|---------------------------|---|---------------------|------|
| <i>C. gigantea</i> Cooper | Porterfield | Pratt Ferry | Ala. | 251 |
| <i>C. magna</i> Cooper | Porterfield | Whitesburg | Tenn. | 252 |
| <i>C. multisinuata</i> Cooper | Porterfield | Botetourt, Pratt Ferry, Whitesburg, Chatham Hill, Edinburg (Liberty Hall) | Ala., Tenn., Va. | 253 |
| <i>C. plana</i> Cooper | Porterfield | Effna | Va. | 254 |
| <i>C. rusti</i> Walcott | Trenton | Trenton, Salona | N. Y., Pa. | 254 |
| <i>C. triangulata</i> Cooper | Porterfield | Effna | Va. | 254 |
| <i>Craniops attenuata</i> Cooper | Wilderness | Carters | Ala. | 240 |
| <i>C. minor</i> (Winchell and Schuchert) | Wilderness-Trenton | Decorah to Prosser | Minn. | 240 |
| <i>C. tenuis</i> Cooper | Wilderness | Bromide (Pooleville) (Mountain Lake) | Okla. | 240 |
| <i>C. trentonensis</i> (Hall) | Wilderness | Nealmont | Pa. | 241 |
| <i>Craspedelia marginata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 773 |
| <i>Cristiferina cristata</i> Cooper | Porterfield | Chatham Hill, Edinburg | Va. | 962 |
| <i>C. cristifera</i> Cooper | Wilderness | Oranda, under Eureka | Va., Nev. | 963 |
| <i>Cyclomyonia peculiaris</i> Cooper | Porterfield | Pratt Ferry | Ala. | 975 |
| <i>Cyclospira bisulcata</i> (Emmons) | Trenton | Coburg | N. Y. | 693 |
| <i>C. ? longa</i> Cooper | Wilderness or Porterfield | Pebble in Rysedorf cgl. | N. Y. | 693 |
| <i>C. parva</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 694 |
| <i>C. preciosa</i> Cooper | Wilderness | Edinburg (Lantz Mills) | Va. | 694 |
| <i>C. quadrata</i> Cooper | Wilderness | Edinburg (Liberty Hall) | Va. | 695 |
| <i>C. sulcata</i> Cooper | Wilderness | Sevier, Chatham Hill | Tenn., Va. | 696 |
| <i>Cyphomena angulata</i> Cooper | Porterfield | Edinburg (Cyrt.-Nid. zone) (Liberty Hall), Shippensburg | Md., Va., Pa. | 841 |
| <i>C. grandis</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 842 |
| <i>C. homostriata</i> (Butts) | Wilderness | Oranda | Va., Pa. | 843 |
| <i>C. ? radialis</i> (Okulitch) | Wilderness | Chaumont | Quebec | 844 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------------|-----------------------------|----------------------------|------|
| <i>Cyrtonotella bella</i> (Schuchert and Cooper) | Ashby | Lincolnshire (Hogskin) | Tenn. | 319 |
| <i>C. crassicostella</i> (Schuchert and Cooper) | Porterfield | Benbolt | Tenn. | 320 |
| <i>C. fasciculata</i> Cooper | Porterfield | Benbolt | Va. | 320 |
| <i>C. grandistriata</i> (Willard) | Porterfield | Botetourt, Effna | Va. | 321 |
| <i>C. magna</i> Cooper | Porterfield | Sevier | Tenn. | 322 |
| <i>C. minor</i> Cooper | Ashby | Lincolnshire | Tenn. | 323 |
| <i>C. subplana</i> Cooper | Porterfield | Edinburg | Va. | 323 |
| | | (<i>Cyrtonotella</i> zone) | | |
| <i>C. subquadrata</i> Cooper | Porterfield | Benbolt | Va. | 324 |
| <i>C. virginiensis</i> Butts | Porterfield | Arline, Botetourt | Va., Tenn. | 325 |
| <i>Cyrtonotella</i> ? sp. 1 | Porterfield | Botetourt | Va. | 326 |
| <i>Dactylogonia alternata</i> Cooper | Marmor | Lenoir, Tumbes | Tenn., Va. | 825 |
| <i>D. concentrica</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 826 |
| <i>D. extensa</i> Cooper | Marmor | Mingan | St. Lawrence River, Quebec | 827 |
| <i>D. geniculata</i> Ulrich and Cooper | Porterfield | Arline, Little Oak | Tenn., Va., Ala. | 827 |
| <i>D. incrassata</i> (Hall) | Marmor | Crown Point | N. Y., Vt. | 828 |
| <i>D. magna</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 829 |
| <i>D. magnifica</i> Cooper | Porterfield | Ward Cove | Tenn. | 830 |
| <i>D. marmorata</i> Cooper | Ashby | Murat | Va. | 831 |
| <i>D. obsoleta</i> (Butts) | Porterfield | Little Oak | Ala. | 831 |
| <i>D. obtusa</i> Cooper | Ashby-Porterfield | Lincolnshire, Arline | Tenn., Va. | 832 |
| <i>D. palustris</i> (Willard) | Porterfield | Farragut | Tenn. | 833 |
| <i>D. parva</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 834 |
| <i>D. prona</i> (Willard) | Ashby | Lincolnshire | Va. | 834 |
| <i>D. sculpturata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 835 |
| <i>D. strasburgensis</i> Cooper | Porterfield | Edinburg | Va. | 835 |
| | | (<i>Cyrtonotella</i> zone) | | |
| <i>D. subaequicostellata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 836 |
| <i>D. transversa</i> Cooper | Porterfield | Botetourt | Va. | 836 |
| <i>Dactylogonia</i> sp. 1 | Porterfield | Benbolt | Tenn., Va. | 837 |
| <i>Dactylogonia</i> sp. 2 | Porterfield | Botetourt | Va. | 838 |
| <i>Dactylogonia</i> sp. 3 | Porterfield | Benbolt | Va. | 838 |
| <i>Dactylogonia</i> sp. 4 | Porterfield | Sevier | Tenn. | 838 |
| <i>Dactylogonia</i> sp. 5 | Porterfield | Effna | Va. | 838 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|------------------------------|---|-------------------------|------|
| <i>Dactylogonia</i> sp. 6 | Porterfield | Probably Benbolt | Tenn. | 839 |
| <i>Dactylogonia</i> sp. 7 | Ashby | Whistle Creek | Va. | 839 |
| <i>Dactylogonia</i> sp. 8 | Porterfield | Poteet (Yellow Branch) | Va. | 840 |
| <i>Dalmanella costellata</i> Cooper | Wilderness | Oranda | Va. | 948 |
| <i>D. crassicostellata</i> Cooper | Trenton | Hermitage | Tenn. | 949 |
| <i>D. rara</i> Cooper | Trenton | Curdsville | Tenn., Va. | 949 |
| <i>D. sculpta</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 950 |
| <i>D. sulcata</i> Cooper | Trenton | Hermitage | Tenn. | 951 |
| <i>D. winchelli</i> Cooper | Wilderness | Decorah (Guttenberg) | Minn. | 953 |
| <i>Desmorthis costata</i> Cooper | Whiterock | Joins | Okla. | 446 |
| <i>D. nevadensis</i> Ulrich and Cooper | Whiterock | Upper Pogonip, Joins | Nev., Okla. | 447 |
| <i>Dictyonites perforata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 188 |
| <i>Didymelasma abruptum</i> Cooper | Wilderness | Rockland | Ontario | 616 |
| <i>D. longicrurum</i> Cooper | Wilderness | Lebanon | Tenn. | 617 |
| <i>Dinorthis atavoides</i> Willard | Ashby | Lincolnshire | Tenn., Va. | 393 |
| <i>D. holdeni</i> (Willard) | Ashby | Elway, Whistle Creek | Tenn., Va. | 395 |
| <i>D. interstriata</i> Willard | Porterfield- Trenton | Trenton, Benbolt | N. Y., Va. | 396 |
| <i>D. sweeneyi</i> (N. H. Winchell) | Trenton | Decorah (Ion) | Iowa, Minn. | 397 |
| <i>D. tenuis</i> Cooper | Porterfield | Sevier, Tellico | Tenn. | 397 |
| <i>D. transversa</i> Willard | Porterfield | Benbolt, Sevier, Shippensburg, Chota, Edinburg (lower) | Md., Pa., Tenn., Va. | 398 |
| <i>D. transversoides</i> Cooper | Porterfield to Wilderness | Dryden | Tenn. | 400 |
| <i>D. venusta</i> Cooper | Porterfield | Red Knobs | Tenn. | 401 |
| <i>D. virginienensis</i> Cooper | Wilderness? | Edinburg, Lantz Mills | Va. | 402 |
| <i>D. willardi</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 402 |
| <i>Diorthelasma parvum</i> Cooper | Porterfield | Pratt Ferry | Ala. | 998 |
| <i>Doleroides compressus</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 456 |
| <i>D. crassus</i> Cooper | Wilderness | Ridley | Ga. | 457 |
| <i>D. extensus</i> Cooper | Wilderness | Ridley | Ga. | 457 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|---|----------------------------|---|----------------------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>D. gibbosus</i> (Billings) | Wilderness | Decorah (Spechts Ferry), Plattin (Macy) | Minn., N. Y., Ontario, Mo. | 458 |
| <i>D. irregularis</i> Cooper | Porterfield- Wilderness | Dryden | Tenn. | 459 |
| <i>D. missouriensis</i> Cooper | Wilderness | Plattin (Macy), Zell | Mo. | 460 |
| <i>D. oklahomensis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 461 |
| <i>D. ottawanus</i> Wilson | Wilderness | Chaumont, Platteville | Ontario, Wis. | 462 |
| <i>D. pervetus</i> (Conrad) | Wilderness | Platteville (McGregor) | Ill., Wis. | 462 |
| <i>D. ? ponderosus</i> Cooper | Porterfield | Botetourt, Effna | Va. | 463 |
| <i>D. regularis</i> Cooper | Wilderness | Wardell, Pierce, Dryden | Tenn., Va. | 464 |
| <i>D. tennesseensis</i> Cooper | Wilderness | Carters, Lebanon, Cane Creek | Ala., Tenn., Va. | 465 |
| <i>D. winchelli</i> Cooper | Wilderness | Decorah (Spechts Ferry) | Minn., Wis. | 466 |
| <i>Doleroides</i> sp. 1 | Wilderness | Pierce | Tenn. | 467 |
| <i>Dorytreta bella</i> Cooper | Marmor | McLish | Okla. | 667 |
| <i>D. ovata</i> Cooper | Marmor | Lenoir | Tenn. | 667 |
| <i>D. ? reversa</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 668 |
| <i>Drepanorhyncha ambigua</i> (Hall) | Trenton | Hull | N. Y. | 627 |
| <i>D. ottawaensis</i> (Billings) | Wilderness | Rockland | Ontario | 628 |
| <i>Ectenoglossa ? lyelli</i> Billings | Marmor | Aylmer (Rockcliffe) | Ontario | 217 |
| <i>E. nympha</i> (Billings) | Whiterock | Table Head | Newfoundland | 218 |
| <i>E. nymphotoidea</i> Cooper | Porterfield | Whitesburg, Paperville, Chatham Hill, Liberty Hall | Tenn., Va. | 218 |
| <i>E. ? rubra</i> Cooper | Wilderness | Bays | Tenn. | 219 |
| <i>E. ? sculpta</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 220 |
| <i>Ectenoglossa</i> sp. 1 | Whiterock | Table Head | Newfoundland | 220 |
| <i>Eichwaldia subtrigonalis</i> Billings | Wilderness | Rockland | Ontario | 947 |
| <i>Elasmothyris concinnula</i> Cooper | Porterfield | Pratt Ferry | Ala. | 985 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|---------------------------|---|----------------------------|------|
| <i>Elliptoglossa ovalis</i> (Bassler) | Porterfield to Trenton | Whitesburg, Oranda, Botetourt, Pratt Ferry, Martinsburg, Edinburg | Ala., Md., Pa., Tenn., Va. | 242 |
| <i>E. rotundata</i> Cooper | Porterfield-Wilderness | Edinburg (Liberty Hall) | Va. | 244 |
| <i>E. sylvanica</i> Cooper | Upper Ord. | Maquoketa (Sylvan), Maquoketa | Okla., Mo. | 244 |
| <i>Eoconulus rectangularis</i> Cooper | Porterfield | Pratt Ferry | Ala. | 283 |
| <i>Eopectodonta alternata</i> (Butts) | Ashby-Trenton | Oranda, Eureka group, Martinsburg (Salona), Salona | Pa., Va., Nev. | 808 |
| <i>E. ? dubia</i> Cooper | Porterfield | Botetourt, Edinburg (Cyrt. zone) | Va. | 810 |
| <i>E. foerstei</i> Cooper | Wilderness | Wells | Tenn. | 811 |
| <i>E. ? triradiata</i> (Butts) | Wilderness | Oranda | Va. | 812 |
| <i>Eopectodonta</i> sp. 1 | Porterfield or Wilderness | Edinburg | Va. | 813 |
| <i>Ephippelasma minutum</i> Cooper | Porterfield | Pratt Ferry | Ala. | 261 |
| <i>Eremotoechia alabamensis</i> Cooper | Porterfield | Little Oak | Ala. | 514 |
| <i>E. cloudi</i> Cooper | Porterfield | Arline | Tenn. | 514 |
| <i>E. silicica</i> Cooper | Porterfield | Pratt Ferry, Arline | Ala., Tenn. | 515 |
| <i>Eremotrema biconvexum</i> Cooper | Porterfield | Benbolt | Va. | 960 |
| <i>Eridorthis inexpecta</i> Cooper | Porterfield | Effna, Edinburg (Liberty Hall) | Va. | 384 |
| <i>Fascifera convexa</i> Cooper | Porterfield | Benbolt | Tenn. | 999 |
| <i>F. dalmanelloidea</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 999 |
| <i>F. stonensis</i> (Safford) | Wilderness | Pierce, Dryden, Wardell, Ridley, Benbolt | Tenn., Ga., Ala., Va. | 1001 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------|---|----------------------------|------|
| <i>F. subcarinata</i> Ulrich and Cooper | Wilderness | Dryden, Ooltewah, Wardell, Ridley | Ga., Tenn., Va. | 1002 |
| <i>F. sulcata</i> Cooper | Wilderness | Carters | Tenn. | 1003 |
| <i>Fascifera</i> sp. 1 | Porterfield | Ward Cove | Va., Tenn. | 1004 |
| <i>Furcitella plicata</i> Cooper | Wilderness | Oranda | Va. | 877 |
| <i>F. scofieldi</i> (Winchell and Schuchert) | Trenton | Prosser | Minn. | 878 |
| <i>Glossella liumbona</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 228 |
| <i>G. papillosa</i> Cooper | Porterfield | Pratt Ferry | Ala. | 229 |
| <i>Glossella</i> sp. 1 | Porterfield | Botetourt | Va. | 229 |
| <i>Glyptambonites glyptus</i> Cooper | Porterfield | Effna, Liberty Hall, Pratt Ferry, Rich Valley | Va., Ala. | 713 |
| <i>G. musculosus</i> Cooper | Wilderness | Oranda | Va. | 715 |
| <i>G. ? platys</i> (Butts) | Porterfield | Edinburg (Cyrtonotella zone) | Va. | 716 |
| <i>Glyptoglossa cavellosa</i> Cooper | Porterfield | Shippensburg (Pinesburg) | Md., Pa. | 227 |
| <i>Glyptoglossa</i> sp. 1 | Porterfield | Effna, Chatham Hill | Va. | 227 |
| <i>Glyptomena ? bella</i> Cooper | Ashby | Murat | Va. | 882 |
| <i>G. ? distans</i> (Raymond) | Marmor | Crown Point | N. Y. | 883 |
| <i>G. ? minganensis</i> (Twenhofel and Stiles) | Marmor | Mingan | St. Lawrence River, Quebec | 883 |
| <i>G. parvula</i> Cooper | Porterfield | Effna-Rich Valley | Va. | 883 |
| <i>G. ? prisca</i> (Raymond) | Marmor | Crown Point | N. Y., Vt. | 884 |
| <i>G. sculpturata</i> Cooper | Porterfield | Chatham Hill | Va. | 885 |
| <i>Glyptomena</i> sp. 1 | Porterfield | Ward Cove? | Va. | 885 |
| <i>Glyptorthis alta</i> Cooper | Trenton | Kimmswick | Mo. | 361 |
| <i>G. assimilis</i> Cooper | Wilderness | Ridley | Tenn. | 361 |
| <i>G. bellarugosa</i> (Conrad) | Trenton? | Decorah (Ion?) | Iowa, Wis. | 363 |
| <i>G. bellatula</i> Cooper | Porterfield | Chatham Hill | Va. | 364 |
| <i>G. concinnula</i> Cooper | Porterfield | Little Oak, Arline | Ala., Tenn., Va. | 365 |
| <i>G. costellata</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 366 |
| <i>G. crenulata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 367 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------|---|---------------------|------|
| <i>G. equiconvexa</i> Cooper | Porterfield | Botetourt, Shippensburg (Pinesburg) | Md., Va. | 368 |
| <i>G. glypta</i> Cooper | Porterfield | Effna, Rich Valley, Pratt Ferry | Va., Ala. | 369 |
| <i>G. irregularis</i> Cooper | Wilderness | Pierce, Wardell, Lebanon | Tenn. | 370 |
| <i>G. multicostellata</i> Cooper | Wilderness | Ridley | Ga. | 371 |
| <i>G. obesa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 372 |
| <i>G. rara</i> Cooper | Porterfield | Benbolt | Va. | 372 |
| <i>G. senecta</i> Cooper | Porterfield | Potet (Yellow Branch) | Va. | 373 |
| <i>G. subcarinata</i> Cooper | Porterfield | Sevier | Tenn. | 374 |
| <i>G. subcircularis</i> Cooper | Trenton | Decorah (Ion) | Minn., Iowa | 374 |
| <i>G. sulcata</i> Cooper | Marmor | Crown Point | N. Y. | 375 |
| <i>G. transversa</i> Cooper | Marmor | St. Martin | Quebec | 376 |
| <i>G. uncinata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 377 |
| <i>G. uniformis</i> Cooper | Porterfield | Benbolt, Sevier | Tenn., Va. | 378 |
| <i>G. uniplicata</i> Cooper | Porterfield | Benbolt | Va. | 379 |
| <i>G. virginica</i> Cooper | Wilderness | Wardell | Va. | 379 |
| <i>Glyptorthis</i> sp. 1 | Wilderness | Dark shale under Eureka quartzite | Nev. | 381 |
| <i>Glyptorthis</i> sp. 2 | Ashby | Lincolnshire (Hogskin) | Tenn. | 382 |
| <i>Glyptorthis</i> sp. 3 | Porterfield | Little Oak | Ala. | 382 |
| <i>Glyptorthis</i> sp. 4 | Marmor | McLish | Okla. | 383 |
| <i>Goniotrema perplexum</i> Ulrich and Cooper | Whiterock | Upper Pogonip | Nev. | 711 |
| <i>Hallina globularis</i> Cooper | Wilderness | Auburn | Mo. | 689 |
| <i>H. lirata</i> Cooper | Wilderness | Benner-Stover | Pa. | 689 |
| <i>H. saffordi</i> Winchell and Schuchert | Wilderness | Lebanon | Tenn. | 690 |
| <i>Hesperinia kirki</i> Cooper | Whiterock | Tank Hill | Nev. | 822 |
| <i>Hesperomena leptellinoidea</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrphia</i> zone) | Nev. | 745 |
| <i>Hesperonomiella minor</i> (Walcott) | Whiterock | Upper Pogonip (<i>Desmorthis</i> zone), Wahwah | Nev., Utah | 337 |
| <i>H. quebecensis</i> Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 337 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|-----------------------|--|---|------|
| <i>Hesperorthis antelopensis</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 344 |
| <i>H. australis</i> Cooper | Wilderness | Wardell, Dryden, Ridley | Tenn., Va. | 345 |
| <i>H. biconvexa</i> Cooper | Ashby | Lincolnshire | Tenn. | 346 |
| <i>H. coleii</i> Cooper | Trenton | Decorah (Ion) | Minn., Iowa | 347 |
| <i>H. concava</i> Cooper | Wilderness | Platteville, Chaumont | Ill., Wis., N. Y. | 348 |
| <i>H. ? costalis</i> (Hall) | Marmor or Wilderness | Crown Point or Chaumont? | N. Y. | 349 |
| <i>H. ? costellata</i> Cooper | Porterfield | Botetourt | Va. | 350 |
| <i>H. crinerensis</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 350 |
| <i>H. ? decipiens</i> (Phleger) | Ashby | Barrel Spring | Calif. | 351 |
| <i>H. dubia</i> Cooper | Porterfield | Sevier | Tenn. | 351 |
| <i>H. ignicula</i> (Raymond) | Marmor | Valcour | N. Y. | 352 |
| <i>H. longirostris</i> Cooper | Ashby | Whistle Creek, Lincolnshire, Ellett | Tenn., Va. | 352 |
| <i>H. matutina</i> Cooper | Ashby | Tulip Creek | Okla. | 353 |
| <i>H. multicosata</i> Cooper | Ashby | Lincolnshire | Tenn. | 354 |
| <i>H. quadrata</i> Cooper | Wilderness | Lebanon | Ga., Tenn. | 355 |
| <i>H. sulcata</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 356 |
| <i>H. tenuicostata</i> Cooper | Marmor | Lenoir | Tenn., Va. | 357 |
| <i>H. tricrenaria</i> (Conrad) | Wilderness to Trenton | Guttenburg, Auburn, Barnhart, Rockland, Curdsville | Ill., N. Y., Mo., Wis., Ky., Va., Ontario | 358 |
| <i>H. virginiensis</i> Cooper | Wilderness | Oranda | Va. | 359 |
| <i>Hesperorthis</i> sp. 1 | Porterfield | Botetourt | Va. | 360 |
| <i>Hesperorthis</i> sp. 2 | Wilderness? | Edinburg (middle <i>Nidulites</i> zone) | Va. | 360 |
| <i>Idiospira ? inornata</i> (Weller) | Wilderness-Trenton | Jacksonburg | N. J. | 691 |
| <i>I. panderi</i> (Billings) | Wilderness-Trenton | Tyrone, Auburn, Hull, Rockland, Guttenberg | Ontario, Quebec, Mo., Ky., N. Y., Iowa | 691 |
| <i>I. ? warthini</i> Cooper | Trenton | Wappinger | N. Y. | 692 |
| <i>Idiostrophia costata</i> Ulrich and Cooper | Whiterock | Boulders in Mystic cgl. | Quebec | 588 |
| <i>I. nuda</i> Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 588 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|-------------------------|---|---------------------------|------|
| <i>I. paucicostata</i> Cooper | Whiterock | Upper Pogonip (<i>Anomalorthis</i> zone) | Nev. | 588 |
| <i>I. perfecta</i> Ulrich and Cooper | Whiterock | Boulders in Mystic cgl., Table Head | Quebec, New- foundland | 589 |
| <i>I. plicata</i> Cooper | Whiterock | Table Head | Newfoundland | 589 |
| <i>Idiostrophia</i> sp. 1 | Whiterock | Boulders in Mystic cgl. | Quebec | 590 |
| <i>Ingria claudi</i> (Ulrich and Cooper) | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 700 |
| <i>Isophragma biseptatum</i> Cooper | Porterfield | Botetourt, Benbolt, Arline | Va. | 734 |
| <i>I. extensum</i> Cooper | Porterfield | Arline, Little Oak | Tenn., Ala. | 735 |
| <i>I. ponderosum</i> Cooper | Ashby or Porterfield | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 737 |
| <i>I. ricevillense</i> Cooper | Porterfield | Athens | Tenn. | 737 |
| <i>I. subabbreviatum</i> Cooper | Porterfield | Arline | Tenn. | 738 |
| <i>I. sulcatum</i> Cooper | Porterfield | "Lenoir"- Little Oak | Ala. | 739 |
| <i>Isophragma</i> sp. 1 | Porterfield | Pratt Ferry | Ala. | 740 |
| <i>Kirkina millardensis</i> Salmon | Whiterock | Rocks equivalent to Upper Pogo- nip-Lehman | Utah | 866 |
| <i>Kullervo ornata</i> Cooper | Porterfield | Effna-Rich Valley | Va. | 527 |
| <i>K. parva</i> Cooper | Porterfield | Effna-Rich Valley, Edinburg (Liberty Hall) | Va. | 527 |
| <i>K. punctata</i> Cooper | Porterfield | Botetourt | Va. | 528 |
| <i>K. sulcata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 529 |
| <i>Laticrura heteropleura</i> Cooper | Porterfield | Little Oak | Ala. | 980 |
| <i>L. latibrachiata</i> Cooper | Porterfield | Arline | Tenn. | 981 |
| <i>L. magna</i> Cooper | Wilderness | Oranda, Martins- burg (Salona) | Pa., Va. | 982 |
| <i>L. pionodema</i> Cooper | Porterfield | Effna-Rich Valley, Edinburg (<i>Cyrt.</i> zone), Liberty Hall | Va. | 983 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|------------------------|--|-----------------------------|------|
| <i>Leptaena ordovicica</i> Cooper | Porterfield-Trenton | Oranda, Rodman, Rysedorf, Carters, Edinburg (Cyr. zone), Martinsburg (Salona), Salona, dark shale under Eureka quartzite | Ala., N. Y., Pa., Va., Nev. | 820 |
| <i>Leptellina abbreviata</i> Cooper | Wilderness | Oranda | Va. | 747 |
| <i>L. bella</i> Cooper | Porterfield | Whitesburg, Chatham Hill | Tenn., Va. | 748 |
| <i>L. delicatula</i> (Butts) | Porterfield | Little Oak | Ala. | 749 |
| <i>L. incompta</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 750 |
| <i>L. occidentalis</i> Ulrich and Cooper | Whiterock | Upper Pogonip (Rhysostrophia zone) | Nev. | 751 |
| <i>L. platys</i> Cooper | Porterfield | Benbolt | Va. | 751 |
| <i>L. primaria</i> Cooper | Marmor | Crown Point | N. Y., Vt. | 752 |
| <i>L. pulchra</i> Cooper | Porterfield | Botetourt, Effna, Pratt Ferry, Rich Valley, Benbolt, Liberty Hall | Ala., Va. | 753 |
| <i>L. subcarinata</i> Cooper | Porterfield | Athens | Tenn. | 754 |
| <i>L. sublamellosa</i> Cooper | Porterfield | Benbolt, Chatham Hill | Va. | 755 |
| <i>L. tennesseensis</i> Ulrich and Cooper | Porterfield | Arline, Red Knobs, Little Oak, Effna, Botetourt, Tellico, Fetzer | Ala., Tenn., Va. | 756 |
| <i>L. transversa</i> Cooper | Porterfield | Arline | Va. | 758 |
| <i>Leptellina</i> sp. 1 | Porterfield | Edinburg (Cyrtonotella zone) | Va. | 759 |
| <i>Leptobolus walcotti</i> Ruedemann | Porterfield-Wilderness | Normanskill | N. Y. | 214 |
| <i>Leptobolus</i> ? sp. 1 | Porterfield-Wilderness | Edinburg (Liberty Hall) | Va. | 214 |
| <i>Leptobolus</i> ? sp. 2 | Porterfield-Wilderness | Edinburg (Liberty Hall) | Va. | 214 |
| <i>Limbimurina brevilimbata</i> Cooper | Porterfield | Edinburg (Cyr. zone), Botetourt | Va. | 852 |
| <i>L. insueta</i> Cooper | Wilderness | Rodman | Pa. | 853 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|---|----------------------------|--|----------------------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>Lingulasma compactum</i> Cooper | Wilderness | Oranda | Va. | 232 |
| <i>L. matutinum</i> Cooper | Porterfield | Arline | Tenn. | 233 |
| <i>L. occidentale</i> Cooper | Ashby or Porterfield | Yellow ls. above 25' ss. in Eureka group | Nev. | 234 |
| <i>L. oklahomense</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 233 |
| <i>Lingulasma</i> sp. 1 | Wilderness | Oranda | Va. | 235 |
| <i>Lingulasma</i> sp. 2 | Porterfield | Shippensburg (Pinesburg) | Md. | 235 |
| <i>Lingulasma</i> sp. 3 | Porterfield- Wilderness | Edinburg (<i>Nidulites</i> zone) | Va. | 235 |
| <i>Lingulella alabamensis</i> Cooper | Porterfield | Pratt Ferry | Ala. | 195 |
| <i>L. brainerdi</i> (Raymond) | Marmor | Chazy group (base) | N. Y., Vt. | 196 |
| <i>L. ? clochensis</i> (Foerste) | Wilderness | "Lowville" | Ontario | 197 |
| <i>L. columba</i> (Raymond) | Marmor | Chazy | N. Y., Vt. | 198 |
| <i>L. decorticata</i> Cooper | Ashby | Elway | Va. | 198 |
| <i>L. endopunctata</i> Cooper | Porterfield | Botetourt (<i>Cybeloides</i> bed) | Va. | 198 |
| <i>L. fostermontensis</i> (Butts) | Wilderness | Attalla | Ala. | 199 |
| <i>L. galba</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 200 |
| <i>L. ? glypta</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 200 |
| <i>L. huronensis</i> (Billings) | Wilderness | Black River | Lake Huron | 201 |
| <i>L. ? huronensis minganensis</i> (Twenhofel and Whiting) | Marmor | Mingan | St. Lawrence River, Quebec | 201 |
| <i>L. kingstonensis</i> (Billings) | Wilderness | Black River | Ontario | 201 |
| <i>L. lirata</i> Cooper | Porterfield | Pratt Ferry, Effna, Whitesburg, Edinburg (Liberty Hall) | Ala., Tenn., Va. | 201 |
| <i>L. morsei</i> (N. H. Winchell) | Wilderness | St. Peter | Minn. | 202 |
| <i>L. narrawayi</i> (Wilson) | Wilderness | Pamelia, Lowville | Quebec and Ontario | 202 |
| <i>L. rideauensis</i> Cooper | Marmor | Aylmer (Rockcliffe) | Ontario | 203 |
| <i>L. rugosilinea</i> Cooper | Marmor | Aylmer (Rockcliffe) | Ontario | 203 |
| <i>L. spicata</i> Cooper | Porterfield | Whitesburg | Tenn. | 204 |
| <i>L. subparallela</i> Cooper | Porterfield | Effna | Va. | 205 |
| <i>L. tenuitesta</i> Cooper | Porterfield | Columbiana | Ala. | 205 |
| <i>L. virginensis</i> Cooper | Porterfield | Benbolt? | Va. | 206 |
| <i>Lingulella</i> sp. 1 | Whiterock | Upper Pogonip (<i>Anomalorthis</i> zone) | Nev. | 206 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---------------------------------------|-------------------------|--|---------------------|------|
| <i>Lingulella</i> sp. 2 | Whiterock | Oil Creek | Okla. | 206 |
| <i>Lingulella</i> ? sp. 3 | Porterfield | Little Oak | Ala. | 207 |
| <i>Lingulella</i> ? sp. 4 | Porterfield | Arline | Tenn. | 207 |
| <i>Lingulella</i> ? sp. 5 | Porterfield | Arline | Tenn. | 207 |
| <i>Lingulella</i> sp. 6 | Marmor | Aylmer (Rockcliffe) | Quebec | 208 |
| <i>Lingulella</i> sp. 7 | Ashby | Dutchtown | Mo. | 208 |
| <i>Lingulella</i> ? sp. 8 | Porterfield | Pratt Ferry | Ala. | 208 |
| <i>Liricamera nevadensis</i> Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 592 |
| <i>Macrocoelia bella</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 891 |
| <i>M. champlainensis</i> (Raymond) | Marmor | Crown Point | N. Y. | 892 |
| <i>M. duplistriata</i> (Willard) | Ashby | Lincolnshire, Lincolnshire (Hogskin) | Tenn., Va. | 893 |
| <i>M. elegantula</i> Cooper | Ashby | Whistle Creek | Va. | 893 |
| <i>M. magna</i> (Butts) | Porterfield | Benbolt | Tenn., Va. | 894 |
| <i>M. obesa</i> Cooper | Porterfield | Arline | Tenn. | 895 |
| <i>M. occidentalis</i> Cooper | Ashby or Porterfield | Yellow ls. on 25' ss., at base of Eureka group | Nev. | 896 |
| <i>M. ornata</i> Cooper | Porterfield | Little Oak | Ala. | 897 |
| <i>M. platys</i> Cooper | Ashby | Lincolnshire | Tenn. | 898 |
| <i>M. plebeia</i> Cooper | Marmor | Lenoir | Tenn. | 899 |
| <i>M. rotunda</i> Cooper | Porterfield | Benbolt | Va. | 899 |
| <i>M. ruedemanni</i> (Salmon) | ? | Boulder in Rysedorf cgl. | N. Y. | 900 |
| <i>Macrocoelia</i> sp. 1 | Marmor | Lenoir | Tenn. | 900 |
| <i>Microtrypa altilis</i> Wilson | Wilderness | Chaumont, Rockland | Ontario | 879 |
| <i>M. ? nasuta</i> Wilson | Wilderness | Rockland | Ontario | 879 |
| <i>Mimella biconvexa</i> Cooper | Wilderness | Ridley, Pierce | Tenn. | 468 |
| <i>M. borealis</i> (Billings) | Marmor | St. Martin | Quebec | 469 |
| <i>M. costellata</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 469 |
| <i>M. extensa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 470 |
| <i>M. gilberti</i> Cooper | Marmor | Ellett | Va. | 471 |
| <i>M. globosa</i> (Willard) | Porterfield | Benbolt, Ridley, Dryden | Tenn., Va., Ga. | 472 |
| <i>M. globularis</i> Cooper | Porterfield | Poteet (Yellow Branch), Ridley | Va., Tenn. | 474 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|-----------------------------|---|----------------------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>M. imperator</i> (Billings) | Marmor | Aylmer (Rockcliffe) | Quebec, Ontario | 475 |
| <i>M. intermedia</i> Cooper | Ashby | Elway, Whistle Creek | Tenn., Va. | 476 |
| <i>M. laticardinia</i> Cooper | Ashby | Murat, Lincolnshire | Va., Tenn. | 477 |
| <i>M. latistriata</i> Wilson | Marmor | Aylmer | Ontario | 478 |
| <i>M. minganensis</i> Twenhofel and Whiting | Marmor | Mingan | St. Lawrence River, Quebec | 479 |
| <i>M. nuclea</i> (Butts) | Marmor | Lenoir | Ala., Tenn. | 479 |
| <i>M. nucleoides</i> Cooper | Marmor | Crown Point | N. Y. | 480 |
| <i>M. piger</i> (Billings) | Marmor | Mingan | St. Lawrence River, Quebec | 481 |
| <i>M. similis</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 481 |
| <i>M. subquadrata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 483 |
| <i>M. sulcata</i> Cooper | Porterfield | Benbolt | Va. | 483 |
| <i>M. transversa</i> Cooper | Marmor | Valcour | N. Y. | 484 |
| <i>M. tumida</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 485 |
| <i>M. ulrichi</i> Cooper | Marmor | Crown Point | N. Y. | 486 |
| <i>M. valcourensis</i> Cooper | Marmor | Probably Valcour | N. Y. | 486 |
| <i>M. virginienensis</i> Cooper | Ashby | Whistle Creek | Va. | 487 |
| <i>M. vulgaris</i> (Raymond) | Marmor | Crown Point, St. Martin | N. Y., Vt., Quebec | 488 |
| <i>M. wardellana</i> Cooper | Wilderness | Wardell | Tenn. | 489 |
| <i>Mimella</i> sp. 1 | Ashby | Elway | Tenn. | 490 |
| <i>Mimella</i> sp. 2 | Ashby | Tulip Creek | Okla. | 490 |
| <i>Mimella</i> sp. 3 | Ashby | Lincolnshire | Va. | 491 |
| <i>Multicostella bursa</i> (Raymond) | Porterfield- Wilderness? | Whitesburg, Chatham Hill, Botetourt | Tenn., Va. | 416 |
| <i>M. convexa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 418 |
| <i>M. fasciculata</i> (Butts) | Porterfield | Little Oak | Ala. | 418 |
| <i>M. gerontica</i> Cooper | Ashby | Lincolnshire | Tenn. | 419 |
| <i>M. parallela</i> Cooper | Ashby or Porterfield | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 420 |
| <i>M. planosulcata</i> Cooper | Porterfield | Arline | Tenn. | 421 |
| <i>M. platys</i> (Billings) | Marmor | Crown Point, St. Martin | N. Y., Vt., Quebec | 421 |
| <i>M. plena</i> Cooper | Porterfield | Arline | Tenn. | 422 |
| <i>M. plicata</i> Cooper | Ashby | Lincolnshire | Tenn. | 423 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|------------------------|--|---------------------|------|
| <i>M. quadrata</i> Cooper | Ashby | Whistle Creek, Ellett | Va. | 424 |
| <i>M. rectangularata</i> Cooper | Ashby or Porterfield | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 425 |
| <i>M. robusta</i> Cooper | Porterfield | Sevier | Tenn. | 426 |
| <i>M. saffordi</i> (Hall and Clarke) | Porterfield | Probably Arline | Tenn. | 427 |
| <i>M. semisulcata</i> Cooper | Ashby | Lincolnshire, Lincolnshire (Hogskin) | Tenn., Va. | 427 |
| <i>M. sulcata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 428 |
| <i>Murinella biconvexa</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 845 |
| <i>M. cancellata</i> Cooper | Porterfield | Benbolt? | Va. | 846 |
| <i>M. muralis</i> Cooper | Porterfield-Wilderness | Poteet (Yellow Branch), Benbolt, Wardell, Dryden | Va. | 846 |
| <i>M. partita</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 847 |
| <i>M. parva</i> Cooper | Ashby | Whistle Creek | Va. | 848 |
| <i>M. plana</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 849 |
| <i>M. semireducta</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 849 |
| <i>M. speciosa</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 850 |
| <i>Murinella</i> sp. 1 | Porterfield | Murfreesboro | Tenn. | 850 |
| <i>Murinella</i> sp. 2 | Ashby | Tulip Creek | Okla. | 851 |
| <i>Murinella</i> sp. 3 | Porterfield | Little Oak | Ala. | 851 |
| <i>Neostrophia ? gregaria</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 590 |
| <i>N. subcostata</i> Ulrich and Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 591 |
| <i>Neostrophia</i> sp. 1 | Porterfield | Ward Cove? | Va. | 591 |
| <i>Nicolella angulata</i> Cooper | Trenton | Wappinger | N. Y. | 317 |
| <i>N. strasburgensis</i> Butts | Wilderness | Oranda | Pa., Va. | 318 |
| <i>Nothorthis delicatula</i> Ulrich and Cooper | Canadian or Whiterock | Boulder in Lévis shale | Quebec | 315 |
| <i>N. tarda</i> Cooper | Porterfield | Pratt Ferry | Ala. | 315 |
| <i>N. transversa</i> Cooper | Porterfield | Pratt Ferry | Ala. | 315 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|------------------------|---|---------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>Obolellina canadensis</i> (Billings) | Wilderness | Leray-Rockland | Ontario | 230 |
| <i>O. dixonensis</i> Cooper | Wilderness | Platteville | Ill. | 230 |
| <i>O. erecta</i> (Wilson) | Wilderness | Leray-Rockland | Ontario | 231 |
| <i>O. magnifica</i> Billings | Wilderness | Rockland | Ontario | 231 |
| <i>O. parva</i> (Whitfield) | Trenton | Prosser | Minn. | 232 |
| <i>O. ? biconvexa</i> Cooper | Porterfield-Wilderness | Paperville | Tenn. | 189 |
| <i>Obolus ? cyane</i> (Billings) | Whiterock | Table Head | Newfoundland | 190 |
| <i>O. ? grandis</i> Cooper | Porterfield | Red Knobs | Tenn. | 190 |
| <i>O. ? nitens</i> Cooper | Porterfield | Rich Valley | Va. | 190 |
| <i>O. ? virginiensis</i> Cooper | Porterfield | Effna, Red Knobs | Va., Tenn. | 191 |
| <i>Obolus</i> sp. 1 | Whiterock | Table Head | Newfoundland | 192 |
| <i>Obolus</i> sp. 2 | Marmor | Blackford | Va. | 192 |
| <i>Obolus</i> sp. 3 | Porterfield | Pratt Ferry | Ala. | 193 |
| <i>Obolus</i> sp. 4 | Porterfield | Pratt Ferry | Ala. | 193 |
| <i>Obolus</i> sp. 5 | Porterfield | Effna | Va. | 193 |
| <i>Oligorhynchia angulata</i> Cooper | Ashby-Wilderness | Lincolnshire (Hogskin), Ward Cove, Sevier | Tenn., Va. | 659 |
| <i>O. bifurcata</i> Cooper | Porterfield-Wilderness | Benbolt, Sevier, Ward Cove, Witten, St. Luke, Surgener | Tenn., Va. | 659 |
| <i>O. elongata</i> Cooper | Wilderness | Wardell | Tenn. | 660 |
| <i>O. inexpectata</i> Cooper | Porterfield | Red Knobs | Tenn. | 661 |
| <i>O. subplana</i> Cooper | Ashby-Porterfield | Lincolnshire, Lincolnshire (Hogskin), Ward Cove, Sevier | Tenn. | 662 |
| <i>O. subplana gibbosa</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 662 |
| <i>Oligorhynchia</i> sp. 1 | Porterfield-Wilderness | Dryden | Tenn. | 663 |
| <i>Onniella ? americana</i> Cooper | Trenton | Hermitage | Tenn. | 953 |
| <i>O. fertilis</i> (Ulrich) | Trenton | Martinsburg (Curdsville) | Tenn., Va. | 954 |
| <i>O. paquettensis</i> Sinclair | Wilderness | Rockland | Ontario | 955 |
| <i>O. ? planoconvexa</i> Cooper | Trenton | Hermitage | Tenn. | 955 |
| <i>Onychoplectia brevirostris</i> Cooper | Marmor | Lenoir | Tenn. | 530 |
| <i>O. gracilis</i> (Raymond) | Marmor | Crown Point | N. Y., Vt. | 531 |
| <i>O. kindlei</i> Cooper | Whiterock | Table Head | Newfoundland | 532 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------|------------------------------------|----------------------------|------|
| <i>O. longirostris</i> (Billings) | Marmor | Mingan | St. Lawrence River, Quebec | 533 |
| <i>O. matutina</i> Cooper | Marmor | Jasper, Everton | Ark. | 534 |
| <i>O. obesa</i> Cooper | Marmor | Row Park | Pa., Md. | 534 |
| <i>O. tenuis</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 535 |
| <i>Onychoplecia</i> sp. 1 | Porterfield | Chota | Tenn. | 536 |
| <i>Öpikina alata</i> Cooper | Porterfield | Edinburg (Nidulites zone) | Va. | 903 |
| <i>Ö. bellula</i> Cooper | Porterfield | Edinburg (Cyr. zone), Shippensburg | Md., Va. | 904 |
| <i>Ö. clara</i> (Okulitch) | Wilderness | Chaumont | Quebec | 905 |
| <i>Ö. dorsatiformis</i> Cooper | Porterfield | Edinburg (Nidulites, Cyrt. zone) | Va. | 905 |
| <i>Ö. ? dubia</i> Cooper | Porterfield | Botetourt | Va. | 906 |
| <i>Ö. eximia</i> Cooper | Wilderness | Lebanon, Camp Nelson | Ky., Tenn. | 906 |
| <i>Ö. expatata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 907 |
| <i>Ö. extensa</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 908 |
| <i>Ö. formosa</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 909 |
| <i>Ö. glabella</i> Cooper | Porterfield | Arline | Tenn. | 910 |
| <i>Ö. gregaria</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 911 |
| <i>Ö. inquassa</i> (Sardeson) | Wilderness | Decorah (Guttenberg) | Minn. | 912 |
| <i>Ö. lirata</i> Cooper | Trenton | Decorah (Ion) | Minn. | 912 |
| <i>Ö. maja</i> Cooper | Wilderness | Ridley | Ga. | 913 |
| <i>Ö. matutina</i> Cooper | Porterfield | Arline | Va. | 913 |
| <i>Ö. minnesotensis</i> (N. H. Winchell) | Wilderness | Platteville (McGregor) | Ill., Minn., Wis. | 914 |
| <i>Ö. nasuta</i> Cooper | Porterfield | Chatham Hill | Va. | 914 |
| <i>Ö. parvula</i> Cooper | Porterfield | Benbolt | Va. | 915 |
| <i>Ö. ? planulata</i> Cooper | Wilderness | Pierce | Tenn. | 916 |
| <i>Ö. pulchella</i> Cooper | Porterfield | Benbolt | Va. | 916 |
| <i>Ö. quadrata</i> Cooper | Wilderness | Ridley | Tenn. | 917 |
| <i>Ö. septata</i> Salmon | Wilderness | Lebanon | Tenn. | 918 |
| <i>Ö. speciosa</i> Cooper | Wilderness | Ridley, Wardell, Dryden, Pierce | Ga., Tenn., Va. | 918 |
| <i>Ö. subplanodorsata</i> Cooper | Wilderness | Wardell | Tenn., Va. | 920 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|------------------------|--|---------------------|------|
| <i>Ö. transitionalis</i> (Okulitch) | Wilderness | Chaumont | Quebec | 921 |
| <i>Ö. transversa</i> Cooper | Porterfield | Ward Cove | Va. | 921 |
| <i>Ö. varia</i> Cooper | Wilderness | Carters, Dryden | Ala., Tenn. | 922 |
| <i>Ö. wagneri</i> (Okulitch) | Wilderness | Chaumont | Quebec | 923 |
| <i>Öpikina</i> sp. 1 | Porterfield | Benbolt | Va. | 924 |
| <i>Öpikina</i> sp. 2 | Wilderness | Bromide (Pooleville) | Okla. | 924 |
| <i>Öpikina</i> sp. 3 | Porterfield | Edinburg (<i>Cyrtotonotella</i> zone) | Va. | 925 |
| <i>Öpikina</i> sp. 4 | Porterfield | Little Oak | Ala. | 925 |
| <i>Öpikina</i> sp. 5 | Ashby | Ellett | Va. | 925 |
| <i>Orbiculoidea eximia</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 275 |
| <i>O. linvillensis</i> Cooper | Wilderness | Oranda | Va. | 276 |
| <i>Orthambonites acutiplicatus</i> (Raymond) | Marmor | Day Point? | N. Y. | 294 |
| <i>O. angulatus</i> Cooper | Porterfield | Arline? | Tenn. | 294 |
| <i>O. bellus</i> Cooper | Porterfield | Chatham Hill | Va. | 295 |
| <i>O. bielsteini</i> Cooper | Wilderness- Trenton | Edinburg, Benbolt, Shippensburg (Pinesburg), Oranda, Martinsburg (Salona) | Md., Pa., Va. | 296 |
| <i>O. bifurcatus</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 297 |
| <i>O. blountensis</i> Cooper | Porterfield | Arline | Tenn., Va. | 298 |
| <i>O. brachiophorus</i> Cooper | Porterfield | Effna-Rich Valley, Botetourt | Va. | 298 |
| <i>O. butsi</i> (Schuchert and Cooper) | Porterfield | Little Oak | Ala. | 300 |
| <i>O. dinorthoides</i> Cooper | Whiterock | Oil Creek | Okla. | 301 |
| <i>O. divaricatus</i> Cooper | Porterfield | Effna-Rich Valley | Va. | 302 |
| <i>O. eucharis</i> (Ulrich and Cooper) | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 303 |
| <i>O. ? exfoliatus</i> (Raymond) | Marmor | Day Point | N. Y. | 303 |
| <i>O. friendsvillensis</i> Cooper | Porterfield | Arline | Tenn. | 303 |
| <i>O. michaelis</i> (Clark) | Whiterock | Swan Peak, Kanos | Utah | 304 |
| <i>O. minus</i> Cooper | Ashby | Tulip Creek | Okla. | 304 |
| <i>O. minusculus</i> (Phleger) | Whiterock | Mazourka, Upper Pogonip | Calif., Nev. | 305 |
| <i>O. minutus</i> Cooper | Marmor | McLish | Okla. | 305 |
| <i>O. mostellerensis</i> Cooper | Porterfield | Little Oak | Ala. | 306 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|------------------------|--|---------------------|------|
| <i>O. multicostellatus</i> Cooper | Porterfield-Wilderness | Edinburg (<i>Cyrt.</i> zone), Oranda | Va. | 307 |
| <i>O. neumani</i> Cooper | Porterfield | Tellico | Tenn. | 307 |
| <i>O. occidentalis</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 308 |
| <i>O. parvicrassicostratus</i> Cooper | Porterfield | Effna, Botetourt, Chatham Hill, Benbolt | Va. | 309 |
| <i>O. paucicostatus</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 310 |
| <i>O. rectangulatus</i> Cooper | Porterfield | Shippensburg (Pinesburg) | Md. | 310 |
| <i>O. rotundiformis</i> Cooper | Porterfield | Athens | Tenn. | 311 |
| <i>O. subconvexus</i> Cooper | Whiterock | Oil Creek | Okla. | 312 |
| <i>O. tennesseensis</i> Cooper | Porterfield | Arline, Botetourt, Little Oak | Tenn. | 313 |
| <i>O. tenuicostatus</i> Cooper | Porterfield | Pratt Ferry | Ala. | 314 |
| <i>Orthidiella carinata</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 338 |
| <i>O. costellata</i> Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 338 |
| <i>O. extensa</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 339 |
| <i>O. longwelli</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 339 |
| <i>Orthidiella</i> sp. 1 | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 340 |
| <i>Orthidium bellum</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 340 |
| <i>O. fimbriatum</i> Cooper | Whiterock | Table Head | Newfoundland | 340 |
| <i>O. gemmiculum</i> (Billings) | Whiterock | Boulders in Lévis cgl. (No. 2) | Quebec | 341 |
| <i>Oxoplecia abnormis</i> Cooper | Porterfield | Effna | Va. | 539 |
| <i>O. costellata</i> Cooper | Ashby | Whistle Creek | Va. | 540 |
| <i>O. depressa</i> Cooper | Porterfield | Effna | Va. | 540 |
| <i>O. cidsonensis</i> Cooper | Ashby | Lincolnshire | Tenn., Va. | 541 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------------------|--|---------------------|------|
| <i>O. filosa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 542 |
| <i>O. gibbosa</i> Cooper | Porterfield | Effna, Ward Cove, Red Knobs, Little Oak | Ala., Tenn., Va. | 543 |
| <i>O. globularis</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 544 |
| <i>O. gouldi</i> Ulrich and Cooper | Porterfield | Bromide (Pooleville) | Okla. | 545 |
| <i>O. holstonensis</i> Willard | Porterfield | Effna, Botetourt, Whitesburg, Red Knobs, Liberty Hall | Tenn., Va. | 545 |
| <i>O. magnaplicata</i> Cooper | Porterfield | Shippensburg (Pinesburg) | Md. | 546 |
| <i>O. marmorata</i> Cooper | Porterfield | Red Knobs | Tenn. | 547 |
| <i>O. monitorensis</i> Cooper | Ashby or Porterfield | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 548 |
| <i>O. multicostellata</i> Cooper | Porterfield | Benbolt, Sevier, Chatham Hill, Edinburg (Cyrt. zone) | Tenn., Va. | 549 |
| <i>O. nevadensis</i> Cooper | Wilderness | Dark beds under Eureka quartzite | Nev. | 550 |
| <i>O. occidentalis</i> (Butts) | Wilderness | Bromide (Pooleville?) | Okla. | 551 |
| <i>O. parva</i> Cooper | Porterfield | Benbolt | Va. | 552 |
| <i>O. pennsylvanica</i> Cooper | Trenton | Salona | Pa. | 553 |
| <i>O. planiventra</i> Cooper | Porterfield | Sevier | Tenn. | 554 |
| <i>O. planulata</i> Cooper | Wilderness | Carters | Ala. | 554 |
| <i>O. plicata</i> Cooper | Porterfield | Red Knobs | Tenn. | 555 |
| <i>O. recta</i> Cooper | Ashby | Lincolnshire, Lincolnshire (Hogskin) | Tenn. | 556 |
| <i>O. simulatrix</i> (Bassler) | Wilderness | Oranda | Md., Pa., Va. | 556 |
| <i>Pachyglossa biconvexa</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 224 |
| <i>P. dorsiconvexa</i> Cooper | Porterfield | Pratt Ferry | Ala. | 225 |
| <i>P. ? elderi</i> (Whitfield) | Wilderness | Platteville (McGregor), Decorah (Spechts Ferry) | Minn., Wis. | 225 |
| <i>P. pachydermata</i> Cooper | Porterfield | Effna, Botetourt, Benbolt, Chatham Hill, Pratt Ferry | Ala., Va. | 225 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|----------------------------|--|--------------------------------|------|
| <i>Palaeoglossa</i> ? <i>belli</i> (Billings) | Marmor | St. Martin | Quebec | 221 |
| <i>P. mysticensis</i> Cooper | Whiterock | Boulders in Mystic cgl. | Quebec | 221 |
| <i>P. ? pulicis</i> (Sinclair) | Wilderness | Black River ? | Quebec | 221 |
| <i>Palaeoglossa</i> sp. 1 | Porterfield | Edinburg (<i>Cyrtotonotella</i> zone) | Va. | 222 |
| <i>Palaeostrophomena angulata</i> Cooper | Porterfield | Botetourt | Va. | 702 |
| <i>P. resupinata</i> Cooper | Porterfield | Benbolt | Tenn., Va. | 704 |
| <i>P. ? rugosa</i> Cooper | Porterfield | Botetourt | Va. | 705 |
| <i>P. superba</i> Cooper | Porterfield | Arline, Fetzter | Tenn. | 706 |
| <i>P. subtransversa</i> Cooper | Porterfield | Arline | Va. | 707 |
| <i>Parallelasma pentagonum</i> Cooper | Porterfield | Pratt Ferry | Ala. | 614 |
| <i>Parastrophina bernensis</i> (Sardeson) | Trenton | Prosser | Iowa, Minn., Wis. | 604 |
| <i>P. bilobata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 605 |
| <i>P. hemiplicata</i> (Hall) | Trenton | Martinsburg (Salona), Salona | Va., Pa. | 606 |
| <i>P. rotundiformis</i> (Willard) | Trenton | Prosser | Iowa | 607 |
| <i>Parastrophina</i> sp. 1 | Trenton | Martinsburg (Salona) | Va. | 608 |
| <i>Parastrophina</i> sp. 2 | Wilderness | Oranda | Va. | 608 |
| <i>Paterula amii</i> Schuchert | Porterfield? | Quebec City, Normanskill, Humber Arm | Quebec, N. Y., Newfoundland | 238 |
| <i>P. perfecta</i> Cooper | Porterfield- Wilderness | Whitesburg, Pratt Ferry, Botetourt, Oranda, Arline, Edinburg (Liberty Hall) | Ala., Tenn., Va. | 238 |
| <i>P. polita</i> Cooper | Wilderness | Viola | Okla. | 239 |
| <i>P. subcircularis</i> Cooper | Porterfield | Stringtown- Womble | Okla. | 239 |
| <i>Paucicostella canadensis</i> Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 712 |
| <i>Paucicrura matutina</i> Cooper | Porterfield | Edinburg (<i>Cyrtotonotella</i> zone), Shippensburg (Pinesburg) | Md., Pa., Va. | 957 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|------------------------|--|---------------------|------|
| <i>P. rogata</i> (Sardeson) | Wilderness-Trenton | Auburn, Prosser, Decorah (Ion) | Mo., Minn., Wis. | 957 |
| <i>P. subplana</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 958 |
| <i>P. virginica</i> Cooper | Porterfield-Wilderness | Edinburg (Nidulites zone) (Liberty Hall) | Va. | 958 |
| <i>Paurorthis catawbensis</i> Butts | Porterfield | Botetourt, Blockhouse, Tellico | Va., Tenn. | 964 |
| <i>P. fasciculata</i> Cooper | Porterfield | Little Oak, Tellico, Arline | Ala., Tenn. | 965 |
| <i>P. fascifera</i> Cooper | Porterfield | Ward Cove | Tenn. | 966 |
| <i>P. gigantea</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 967 |
| <i>P. longa</i> Cooper | Porterfield | Arline | Tenn. | 968 |
| <i>P. macrodelloidea</i> Cooper | Wilderness | Bromide (Mountain Lake) | Okla. | 969 |
| <i>P. magna</i> Cooper | Ashby | Lincolnshire, Lincolnshire (Hogskin) | Tenn. | 969 |
| <i>P. ponderosa</i> Cooper | Porterfield | Benbolt, Sevier, Shippensburg (Pinesburg) | Md., Tenn., Va. | 971 |
| <i>P. spinosa</i> Cooper | Porterfield-Wilderness | Edinburg (Nidulites zone) | Va. | 972 |
| <i>Paurorthis</i> sp. 1 | Porterfield | Athens | Tenn. | 973 |
| <i>Paurorthis</i> sp. 2 | Porterfield | Sevier | Tenn. | 974 |
| <i>Pelonomia delicatula</i> (Billings) | Whiterock | Table Head | Newfoundland | 699 |
| <i>Perimecocoelia elliptica</i> Cooper | Porterfield | Arline | Tenn. | 594 |
| <i>P. semicostata</i> Cooper | Porterfield | Effna, Botetourt, Benbolt, Pratt Ferry, Liberty Hall, Edinburg | Ala., Va. | 594 |
| <i>P. triangulata</i> Cooper | Porterfield | Effna | Va. | 596 |
| <i>Petrocrania cicatricula</i> Willard | Ashby? | Probably Lincolnshire (Hogskin) | Tenn. | 287 |
| <i>P. dixonensis</i> Cooper | Wilderness | Platteville | Ill. | 287 |
| <i>P. halli</i> (Sardeson) | Wilderness-Trenton | Decorah (Spechts Ferry) | Minn. | 288 |
| <i>P. inflata</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 288 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---------------------------------------|----------------------|---|--|------|
| <i>P. ? magna</i> Cooper | Porterfield | Effna | Va. | 289 |
| <i>P. prona</i> (Raymond) | Marmor | Crown Point, Mingan | N. Y., St. Lawrence River, Quebec | 289 |
| <i>P. trentonensis</i> (Hall) | Trenton | Martinsburg (Salona) | Va. | 290 |
| <i>Petrocrania</i> sp. 1 | Wilderness | Ridley, Dryden | Ga., Tenn. | 290 |
| <i>Petrocrania</i> ? sp. 2 | Porterfield | Liberty Hall | Va. | 290 |
| <i>Petrocrania</i> sp. 3 | Porterfield | Bromide (Mountain Lake) | Okla. | 291 |
| <i>Petroria rugosa</i> Wilson | Probably Canadian | Beaverfoot | British Columbia | 746 |
| <i>Philhedra depressa</i> Cooper | Porterfield | Prosser | Wis. | 291 |
| <i>P. ferruginea</i> Cooper | Wilderness | Red Knobs | Tenn. | 291 |
| <i>P. minor</i> Cooper | Porterfield | Pierce | Tenn. | 292 |
| <i>Philhedra</i> ? sp. 1 | Porterfield | Bromide (Mountain Lake) | Okla. | 292 |
| <i>Phragmorthis buttsi</i> Cooper | Porterfield | Effna-Rich Valley, Pratt Ferry, Arline, Liberty Hall | Ala., Tenn., Va. | 510 |
| <i>P. crassa</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 511 |
| <i>Pionodema camerata</i> Cooper | Wilderness | Sevier (Bacon Bend) | Tenn. | 986 |
| <i>P. circularis</i> (N. H. Winchell) | Trenton | Decorah (Ion) | Iowa, Minn., Wis. | 987 |
| <i>P. conradi</i> (N. H. Winchell) | Wilderness | Platteville (McGregor) | Ill., Minn., Wis. | 988 |
| <i>P. crassipunctata</i> Cooper | Porterfield | Benbolt | Va. | 989 |
| <i>P. minnesotensis</i> Cooper | Trenton | Decorah (Ion?) | Minn. | 990 |
| <i>P. minuscula</i> Willard | Wilderness | Lebanon, Hatter, Camp Nelson, Witten | Tenn., Pa., Ky., Va. | 991 |
| <i>P. sinuata</i> Okulitch | Wilderness | Chaumont | Quebec | 992 |
| <i>P. subaequata</i> (Conrad) | Wilderness | Decorah (Spechts Ferry, Guttenberg), Auburn, Barnhart | Iowa, Minn., Wis., Mo. | 992 |
| <i>P. sulcata</i> Cooper | Wilderness | Nealmont, Cane Creek | Pa., Va. | 994 |
| <i>P. tennesseensis</i> Cooper | Trenton | Hermitage | Tenn. | 995 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|----------------------------|---|-------------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>P. uniplicata</i> Cooper | Wilderness-Trenton | Decorah (Specchts Ferry-Ion) | Iowa, Minn. Wis. | 996 |
| <i>Pionodema</i> sp. 1 | Wilderness | Chaumont | N. Y. | 996 |
| <i>Pionomena</i> ? <i>dubia</i> Cooper | Porterfield | Effna | Va. | 901 |
| <i>P. neumani</i> Cooper | Ashby | Elway, New Market, Lincolnshire | Md., Pa., Tenn., Va. | 902 |
| <i>P. pulchra</i> Cooper | Wilderness | Grazier | Pa. | 903 |
| <i>Platymena</i> ? <i>bellatula</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 880 |
| <i>P. plana</i> Cooper | Porterfield | Arline | Tenn. | 880 |
| <i>Plectocamara aseptata</i> Cooper | Porterfield | Benbolt, Ward Cove, Sevier | Tenn., Va. | 597 |
| <i>P. costata</i> Cooper | Ashby | Lincolnshire, Lincolnshire (Hogskin), Ward Cove | Tenn., Va. | 598 |
| <i>P. erecta</i> Cooper | Wilderness | Wardell | Tenn. | 599 |
| <i>P. magna</i> Cooper | Porterfield | Edinburg (<i>Cyrt.</i>), Shippensburg (Pinesburg) | Md., Va. | 600 |
| <i>P. rotunda</i> Cooper | Porterfield | Chatham Hill | Va. | 600 |
| <i>P. sulcata</i> Cooper | Porterfield | Benbolt | Va. | 601 |
| <i>P. transversa</i> Cooper | Porterfield- Wilderness | Edinburg (<i>Nidulites</i> zone) | Va. | 602 |
| <i>Plectoglossa oklahomensis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 222 |
| <i>Plectoglossa</i> sp. 1 | Porterfield | Benbolt | Va. | 223 |
| <i>Plectorthis australis</i> Cooper | Porterfield | Arline, Little Oak | Tenn., Ala. | 447 |
| <i>P. compacta</i> Cooper | Porterfield | Arline | Tenn. | 448 |
| <i>P. lebanonensis</i> Cooper | Wilderness | Lebanon | Tenn. | 449 |
| <i>P. mazourkaensis</i> Phleger | Ashby | Mazourka | Calif. | 450 |
| <i>P. obesa</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 450 |
| <i>P. patula</i> (Phleger) | Ashby | Mazourka | Calif. | 450 |
| <i>P. pennsylvanica</i> Cooper | Wilderness | Rodman | Pa. | 451 |
| <i>P. ponderosa</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 451 |
| <i>P. punctata</i> Cooper | Ashby | Tulip Creek | Okla. | 452 |
| <i>P. symmetrica</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 453 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|----------------------------|--|---------------------|------|
| <i>P. tenuis</i> Cooper | Porterfield | Benbolt | Va. | 454 |
| <i>P. transversa</i> Cooper | Porterfield | Ward Cove | Va. | 454 |
| <i>Plectorthis</i> sp. 1 | Porterfield- Wilderness | Shippensburg (Pinesburg) | Pa. | 455 |
| <i>Plectorthis</i> sp. 2 | Porterfield | Murfreesboro | Tenn. | 455 |
| <i>Pleurorthis convexa</i> Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 329 |
| <i>P. corinna</i> (Billings) | Whiterock | Boulder in Mystic cgl. | Quebec | 330 |
| <i>P. costellata</i> Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 330 |
| <i>P. fascicostellata</i> Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 331 |
| <i>P. imbecilis</i> (Billings) | Whiterock | Table Head | Newfoundland | 331 |
| <i>P. tritonia</i> (Billings) | Whiterock | Boulder in Lévis shale (boulder No. 2) | Quebec | 332 |
| <i>Pleurorthis</i> sp. 1 | Whiterock | Table Head | Newfoundland | 332 |
| <i>Pleurorthis</i> sp. 2 | Whiterock | Table Head | Newfoundland | 333 |
| <i>Porambonites</i> ? <i>umbonatus</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 609 |
| <i>Porambonites</i> ? sp. 1 | Whiterock | Upper Pogonip (<i>Anomalorthis</i> zone) | Calif. | 609 |
| <i>Porambonites</i> ? sp. 2 | Whiterock | Table Head | Newfoundland | 610 |
| <i>Porambonites</i> ? sp. 3 | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 610 |
| <i>Porambonites</i> sp. 4 | Trenton | Salona | Pa. | 611 |
| <i>Productorthis agileria</i> (Willard) | Porterfield | Effna | Va. | 335 |
| <i>P. americana</i> Cooper | Porterfield | Arline, Botetourt, Little Oak | Tenn., Ala. | 336 |
| <i>Protorhyncha dubia</i> (Hall) | Marmor | Chazy | N. Y. | 618 |
| <i>Protozyga costata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 676 |
| <i>P. elongata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 677 |
| <i>P. exigua</i> (Hall) | Wilderness | Rockland (Napanee) | N. Y. | 678 |
| <i>P. loeblichii</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 679 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|-----------------------|--|-------------------------|------|
| <i>P. magnicostata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 680 |
| <i>P. microscopica</i> Cooper | Ashby- Porterfield | Elway, Ward Cove, Lincolnshire (Hogskin) | Tenn., Va. | 681 |
| <i>P. nasuta</i> Cooper | Ashby | Whistle Creek | Va. | 681 |
| <i>P. nicolleti</i> (Winchell and Schuchert) | Wilderness | Platteville (McGregor) | Ill., Minn., Wis. | 682 |
| <i>P. profunda</i> Cooper | Trenton | Trenton | Quebec | 683 |
| <i>P. rotunda</i> Cooper | Wilderness | Lebanon, Ridley, Wardell, Plattin (Macy), Barn- hart, Dryden | Ga., Mo., Tenn., Va. | 683 |
| <i>P. rotundiformis</i> Cooper | Ashby | Lincolnshire | Tenn. | 685 |
| <i>P. superba</i> Cooper | Wilderness | Auburn, Barnhart | Mo. | 686 |
| <i>P. tumida</i> Cooper | Porterfield | Effna | Va. | 687 |
| <i>P. uniplicata</i> Cooper | Porterfield | Benbolt, Murfreesboro | Va. | 687 |
| <i>Protozyga</i> sp. I | Porterfield | Meadow | Tenn. | 688 |
| <i>Pseudobolus gibbosus</i> (Willard) | Ashby | Murat | Va. | 194 |
| <i>Pseudobolus</i> sp. I | Porterfield | Effna | Va. | 195 |
| <i>Pseudolingula aquilina</i> Sinclair | Marmor? | Chazy? | Quebec | 215 |
| <i>P. ? eva</i> (Billings) | Wilderness | Black River? | Quebec | 215 |
| <i>P. ? imperfecta</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 215 |
| <i>P. ? luttrellensis</i> Cooper | Wilderness | Moccasin | Tenn. | 216 |
| <i>P. pyxidata</i> Sinclair | Wilderness | Black River? | Quebec | 217 |
| <i>P. ? sculptata</i> Cooper | Wilderness | Camp Nelson | Ky. | 217 |
| <i>Pseudolingula</i> sp. I | Porterfield | Shippensburg (Pinesburg) | Md. | 217 |
| <i>Ptychoglyptus ? kindlei</i> Cooper | Whiterock | Table Head, boulder in Mystic cgl. | Newfoundland, Quebec | 816 |
| <i>P. ? matura</i> Cooper | Porterfield | Pratt Ferry | Ala. | 817 |
| <i>P. virginiensis</i> Willard | Porterfield | Effna, Pratt Ferry, Botetourt, Edinburg, Liberty Hall, Rich Valley | Ala., Tenn., Va. | 818 |
| <i>Ptychoglyptus ?</i> sp. I | Whiterock | Boulder in Mystic cgl. | Quebec | 819 |
| <i>Ptychopleurella globularis</i> Cooper | Porterfield | Arline | Tenn. | 385 |

ANNOTATED LIST OF GENERA AND SPECIES—*Concluded*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|------------------------|--|---------------------|------|
| <i>P. glypta</i> Cooper | Marmor | Lenoir | Tenn. | 386 |
| <i>P. lamellosa</i> (Raymond) | Marmor | Crown Point | N. Y. | 387 |
| <i>P. mediocostata</i> Cooper | Porterfield | Effna-Rich Valley | Va. | 387 |
| <i>P. oklahomensis</i> Cooper | Marmor | McLish | Okla. | 388 |
| <i>P. porcia</i> (Billings) | Marmor | St. Martin | Quebec | 389 |
| <i>P. rectangulata</i> Cooper | Porterfield | Effna-Rich Valley | Va. | 389 |
| <i>P. sulcata</i> Cooper | Wilderness | Oranda | Va. | 390 |
| <i>P. uniplicata</i> Cooper | Porterfield | Benbolt | Va. | 391 |
| <i>Rafinesquina lennoxensis</i> Salmon | Wilderness | Rockland (Napanee) | N. Y., Ontario | 886 |
| <i>R. olliformis</i> Salmon | Wilderness | Rockland (Napanee) | Ontario | 886 |
| <i>R. planulata</i> Cooper | Wilderness | Oranda | Va. | 886 |
| <i>R. prestonensis</i> Salmon | Wilderness | Rockland, Decorah (Guttenberg) | Ill. | 887 |
| <i>R. sinclairi</i> Salmon | Wilderness | Auburn, Barn- hart, Decorah (Guttenberg) | Mo., Wis. | 887 |
| <i>R. trentonensis</i> (Conrad) | Wilderness- Trenton | Decorah (Guttenberg), Hermitage | Wis., Tenn. | 888 |
| <i>Reuschella americana</i> Cooper | Wilderness | Oranda, Jacksonburg | Va., N. J., Pa. | 976 |
| <i>R. edsoni</i> (Bassler) | Trenton | Sherman Fall | Vt. | 978 |
| <i>R. vespertina</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 979 |
| <i>Rhipidomena filicostellata</i> Cooper | Porterfield | Sevier | Tenn. | 867 |
| <i>R. mesleri</i> Cooper | Ashby | Lincolnshire (Hogskin) | Tenn. | 868 |
| <i>R. subparallela</i> Cooper | Ashby | Elway | Tenn. | 870 |
| <i>R. tennesseensis</i> (Willard) | Porterfield | Benbolt | Tenn., Va. | 870 |
| <i>R. tenuitesta</i> (Willard) | Ashby | Lincolnshire, Lincolnshire (Hogskin) | Tenn., Va. | 872 |
| <i>Rhipidomena</i> sp. 1 | Porterfield | Arline | Tenn. | 873 |
| <i>Rhynchotrema kentuckiense</i> Fenton and Fenton | Trenton | Trenton | Ky. | 629 |
| <i>R. wisconsinense</i> Fenton and Fenton | Trenton | Decorah (Ion) | Minn., Wis. | 630 |
| <i>Rhysostrophia elliptica</i> Ulrich and Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 559 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|-------------|--|----------------------------------|------|
| <i>R. nevadensis</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 559 |
| <i>R. occidentalis</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 559 |
| <i>R. transversa</i> Ulrich and Cooper | Whiterock | Boulder in Mystic cgl. | Quebec | 559 |
| <i>Rhysostrophia</i> sp. 1 | Whiterock | Upper Pogonip | Nev. | 560 |
| <i>Rhysostrophia</i> sp. 2 | Whiterock | Table Head | Newfoundland | 560 |
| <i>Rhysotretra corrugata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 259 |
| <i>Rostricellula acutiplicata</i> Cooper | Trenton | Prosser | Minn. | 630 |
| <i>R. ainsliei</i> (N. H. Winchell) | Wilderness | Decorah (Spechts Ferry) | Minn. | 631 |
| <i>R. ? angulata</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 632 |
| <i>R. basalaris</i> Cooper | Marmor | Mosheim, Lenoir, Tumbez, Row Park | Ala., Pa., Tenn., Va. | 632 |
| <i>R. colei</i> Cooper | Trenton | Decorah (Ion) | Iowa, Minn. | 634 |
| <i>R. compressa</i> Cooper | Wilderness | Camp Nelson, Lebanon, Wells | Ky., Tenn. | 634 |
| <i>R. costata</i> Cooper | Marmor | Lenoir | Ala. | 636 |
| <i>R. cuneata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 637 |
| <i>R. cuneiformis</i> (Fenton and Fenton) | Wilderness | Plattin (Macy), Barnhart | Mo. | 637 |
| <i>R. decorahensis</i> (Fenton and Fenton) | Wilderness | Decorah (member?) | Iowa | 638 |
| <i>R. elliptica</i> Cooper | Marmor | New Market | Va. | 638 |
| <i>R. major</i> (Raymond) | Marmor | Valcour | N. Y. | 639 |
| <i>R. minnesotensis</i> (Sardeson) | Wilderness | Platteville (McGregor), Decorah (Spechts Ferry) | Ill., Minn., Wis. | 639 |
| <i>R. ? minuta</i> Cooper | Trenton | Hermitage | Tenn. | 640 |
| <i>R. missouriensis</i> (Fenton and Fenton) | Wilderness | Barnhart, Plattin (Macy) | Mo. | 641 |
| <i>R. multicostrata</i> Cooper | Marmor | Ellett | Va. | 641 |
| <i>R. nucleolata</i> Cooper | Wilderness | Platteville (Pecatonica) | Minn. | 642 |
| <i>R. orientalis</i> (Billings) | Marmor | Mingan | St. Lawrence River, Quebec | 642 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|-------------|--|----------------------------------|------|
| <i>R. ovata</i> Cooper | Wilderness | Hostler, Wardell, Dryden, Ooltewah | Pa., Tenn., Va. | 642 |
| <i>R. parva</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 643 |
| <i>R. plattinensis</i> (Fenton) | Wilderness | Plattin (lower) | Mo. | 644 |
| <i>R. plena</i> (Hall) | Marmor | Aylmer, Valcour, Row Park, St. Martin | N. Y., Vt., Pa., Quebec, Ontario | 645 |
| <i>R. plena altilis</i> (Hall) | Marmor | Valcour | N. Y. | 646 |
| <i>R. plena plicifera</i> (Hall) | Marmor | Valcour | N. Y. | 646 |
| <i>R. pristina</i> (Raymond) | Marmor | Crown Point | N. Y. | 646 |
| <i>R. pulchra</i> Cooper | Wilderness | Decorah (Guttenberg) | Minn. | 646 |
| <i>R. raymondi</i> Cooper | Marmor | St. Martin | Quebec | 647 |
| <i>R. rostrata</i> Ulrich and Cooper | Wilderness | Benbolt, Ridley, Wardell, Dryden, Pierce | Tenn., Va. | 648 |
| <i>R. rotundata</i> Cooper | Wilderness | Swift Current, Cloche Island | Ontario | 649 |
| <i>R. subtransversa</i> Cooper | Wilderness | Witten | Tenn. | 650 |
| <i>R. transversa</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 651 |
| <i>R. triangulata</i> Cooper | Marmor | Mingan | St. Lawrence River, Quebec | 652 |
| <i>R. truncata</i> Cooper | Wilderness | Lebanon | Tenn. | 652 |
| <i>R. tumidula</i> Cooper | Wilderness | Dryden | Va. | 653 |
| <i>R. variabilis</i> Cooper | Wilderness | Ridley | Ga. | 654 |
| <i>R. varicosta</i> Cooper | Marmor | Lenoir (Douglas Lake) | Tenn. | 654 |
| <i>R. wilsonae</i> Cooper | Marmor | Aylmer (Rockcliffe) | Ontario | 655 |
| <i>Rostricellula</i> sp. 1 | Wilderness | Bromide (Pooleville) | Okla. | 656 |
| <i>Rostricellula</i> sp. 2 | Wilderness | Wardell | Va. | 657 |
| <i>Rostricellula</i> sp. 3 | Trenton | Prosser | Minn. | 657 |
| <i>Salonia magnaplicata</i> Cooper and Whitcomb | Trenton | Salona | Pa. | 615 |
| <i>Scaphelasma septatum</i> Cooper | Porterfield | Pratt Ferry | Ala. | 260 |
| <i>Scaphorthis kayi</i> Cooper | Porterfield | Edinburg (Cyrtonotella zone), Shippensburg (Pinesburg) | Md., Pa., Va. | 503 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|----------------------------|---------------------------------------|---|------|
| <i>S. perplexa</i> Cooper | Porterfield | Effna-Rich Valley, Botetourt | Va. | 504 |
| <i>S. virginiensis</i> Cooper | Porterfield | Chatham Hill | Va. | 505 |
| <i>Scaphorthis</i> sp. 1 | Porterfield | Effna-Rich Valley | Va. | 506 |
| <i>Schizambon cuneatum</i> Willard | Porterfield | Effna, Botetourt | Va. | 265 |
| <i>S. duplicimuratum</i> Hudson | Marmor | Crown Point, Mingan, St. Martin | N. Y., Quebec, St. Lawrence River | 266 |
| <i>S. hirsutum</i> Cooper | Ashby | Murat | Va. | 266 |
| <i>S. irregulare</i> Cooper | Porterfield | Arline | Tenn. | 267 |
| <i>S. lineatum</i> Cooper | Wilderness | Wardell | Va. | 267 |
| <i>S. macrothyris</i> Cooper | Porterfield- Wilderness | Benbolt, Wardell | Va. | 267 |
| <i>S. perspinosum</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 268 |
| <i>S. subradiatum</i> Cooper | Porterfield | Arline | Tenn. | 269 |
| <i>Schizambon</i> sp. 1 | Porterfield | Effna-Rich Valley | Va. | 270 |
| <i>Schizambon</i> sp. 2 | Porterfield | Pratt Ferry | Ala. | 270 |
| <i>Schizocrania filosa</i> (Hall) | Wilderness- Trenton | Barnhart, Martinsburg | Mo., Va. | 275 |
| <i>Schizotreta canadensis</i> Wilson | Wilderness | Chaumont | Ontario | 277 |
| <i>S. corrugata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 277 |
| <i>S. microthyris</i> Cooper | Wilderness | Oranda | Va. | 278 |
| <i>S. pannea</i> (Willard) | Porterfield | Effna | Va. | 279 |
| <i>S. papilliformis</i> Ruedemann | Porterfield- Wilderness | Normanskill (Mount Merino) | N. Y. | 279 |
| <i>S. posteroconvexa</i> Cooper | Porterfield | Athens | Tenn. | 279 |
| <i>S. shuleri</i> (Willard) | Porterfield | Effna, Botetourt, Rich Valley | Va. | 280 |
| <i>S. subconica</i> Cooper | Porterfield | Pratt Ferry | Ala. | 281 |
| <i>S. willardi</i> Cooper | Porterfield | Pratt Ferry | Ala. | 281 |
| <i>Schizotreta</i> sp. 1 | Ashby | Lincolnshire (Hogskin) | Tenn. | 282 |
| <i>Siphonotreta americana</i> Cooper | Porterfield | Arline | Tenn. | 263 |
| <i>Skenidioides anthonensis</i> (Sardeson) | Wilderness | Platteville (Pecatonica) | Ill., Minn. | 491 |
| <i>S. billingsi</i> Schuchert and Cooper | Wilderness | Rockland | Ontario | 492 |
| <i>S. convexus</i> Cooper | Porterfield | Pratt Ferry | Ala. | 492 |
| <i>S. costatus</i> Cooper | Porterfield | Liberty Hall, Red Knobs | Tenn., Va. | 493 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|----------------------------|---|----------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>S. elongatus</i> Cooper | Trenton | Martinsburg (Salona) | Va. | 494 |
| <i>S. halli</i> (Hall and Clarke) | Wilderness | Lebanon | Tenn. | 495 |
| <i>S. mediocostatus</i> Cooper | Porterfield | Chatham Hill, Benbolt | Va. | 496 |
| <i>S. obtusus</i> Cooper | Porterfield- Wilderness | Edinburg (<i>Nidulites</i> zone) | Va. | 497 |
| <i>S. oklahomensis</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 498 |
| <i>S. perfectus</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 499 |
| <i>S. platys</i> Cooper | Porterfield | Little Oak | Ala. | 500 |
| <i>S. rectangulatus</i> Cooper | Wilderness | Oranda | Pa., Va. | 500 |
| <i>S. transversus</i> Cooper | Porterfield | Effna-Rich Valley | Va. | 501 |
| <i>Sowerbyella aequicostellata</i> Cooper | Porterfield | Edinburg (<i>Nid.</i> and <i>Cyr- tonotella</i> zone), Shippensburg (Pinesburg) | Md., Pa., Va. | 774 |
| <i>S. aequistriata</i> (Willard) | Wilderness | Wardell | Tenn. | 775 |
| <i>S. angulata</i> Cooper | Trenton | Hermitage | Ala. | 776 |
| <i>S. bellarugosa</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 777 |
| <i>S. cava</i> Cooper | Wilderness | Oranda, Martins- burg (Salona), Salona | Pa., Va. | 777 |
| <i>S. compacta</i> Cooper | Porterfield | Benbolt, Dryden | Ala., Tenn., Va. | 778 |
| <i>S. curdsvillensis</i> (Foerste) | Trenton | Martinsburg (Curdsville) | Ky., Tenn., Va. | 780 |
| <i>S. eximia</i> Cooper | Wilderness- Trenton | Oranda, Martins- burg (Salona) | Va. | 781 |
| <i>S. indistincta</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 782 |
| <i>S. lebanonensis</i> Bassler | Wilderness | Lebanon | Tenn. | 782 |
| <i>S. medioplicata</i> Cooper | Ashby | Lincolnshire | Va. | 784 |
| <i>S. merriami</i> Cooper | Wilderness | Dark shale under Eureka quartzite | Nev. | 785 |
| <i>S. monilifera</i> Cooper | Trenton | Decorah (Ion) | Iowa, Minn., Wis. | 785 |
| <i>S. nasuta</i> Cooper | Porterfield | Chatham Hill | Va. | 787 |
| <i>S. negritus</i> (Willard) | Porterfield | Effna, Ward Cove, Botetourt, Chatham Hill, Whitesburg | Va. | 788 |
| <i>S. parva</i> Cooper | Porterfield | Ward Cove | Va. | 789 |
| <i>S. perplexa</i> Cooper | Porterfield | Chatham Hill | Va. | 790 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|-------------------------|---|---------------------------------------|------|
| <i>S. plicatifera</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 791 |
| <i>S. punctostriata</i> (Mather) | Wilderness | Rockland, Decorah (Guttenberg) | N. Y., Ontario, Minn., Wis. | 792 |
| <i>S. silicica</i> Cooper | Porterfield | Arline | Va. | 793 |
| <i>S. silicica nana</i> Cooper | Porterfield | Arline | Va. | 794 |
| <i>S. socialis</i> Cooper | Wilderness | Wardell | Tenn., Va. | 794 |
| <i>S. socialis crassa</i> Cooper | Wilderness | Wardell | Tenn., Va. | 796 |
| <i>S. subcarinata</i> (Ulrich) | Wilderness | Carters | Ala. | 797 |
| <i>S. variabilis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 798 |
| <i>S. varicostellata</i> Cooper | Porterfield | Arline, Little Oak | Ala., Tenn. | 799 |
| <i>S. vulgata</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 801 |
| <i>Sowerbyella</i> sp. 1 | Porterfield | Bromide (Mountain Lake) | Okla. | 802 |
| <i>Sowerbyella</i> sp. 2 | Wilderness | Rodman | Pa. | 802 |
| <i>Sowerbyella</i> sp. 3 | Wilderness | Dark shale under Eureka quartzite | Nev. | 803 |
| <i>Sowerbyella</i> sp. 4 | Ashby or Porterfield | Yellow ls. on 25' ss. at base of Eureka group | Nev. | 803 |
| <i>Sowerbyites delicatus</i> Cooper | Porterfield | Sevier | Tenn. | 725 |
| <i>S. gildersleevei</i> Cooper | Ashby | Lincolnshire | Va. | 725 |
| <i>S. hami</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 727 |
| <i>S. lamellosus</i> Cooper | Ashby- Porterfield | Bromide (Mountain Lake) Tellico, Great Basin | Okla., Nev., Tenn., Great Basin | 728 |
| <i>S. subnasutus</i> Cooper | Ashby | Lincolnshire | Va. | 729 |
| <i>S. triseptatus</i> (Willard) | Ashby | Lincolnshire, Lincolnshire (Hogskin) | Tenn., Va. | 730 |
| <i>Sowerbyites</i> sp. 1 | Ashby or Porterfield | Quebec City | Quebec | 732 |
| <i>Sphenotreta acutirostris</i> (Hall) | Marmor | Crown Point | N. Y., Vt. | 664 |
| <i>S. cuneata</i> Cooper | Porterfield | Sevier | Tenn. | 665 |
| <i>S. sulcata</i> Cooper | Marmor | McLish | Okla. | 666 |
| <i>Spinilingula intralamellata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 210 |
| <i>Spondylotreta concentrica</i> Cooper | Porterfield | Pratt Ferry | Ala. | 255 |
| <i>S. ? declivis</i> (Willard) | Porterfield | Effna | Va. | 256 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|--------------------|---|---------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>Stenocamara bicosata</i> Cooper | Marmor | Mosheim | Ala. | 603 |
| <i>S. perplexa</i> Cooper | Marmor-Ashby | Mosheim, Whistle Creek, Ellett | Ala., Tenn., Va. | 603 |
| <i>Strophomena anomala</i> Cooper | Porterfield | Benbolt | Va. | 927 |
| <i>S. auburnensis</i> Fenton | Wilderness | Auburn, Decorah (Spechts Ferry, Guttenberg) | Mo., Ill., Wis. | 928 |
| <i>S. auburnensis impressa</i> Raasch | Wilderness | Platteville | Wis. | 928 |
| <i>S. auburnensis nasuta</i> Cooper | Wilderness | Carters, Tyrone | Ky., Tenn. | 929 |
| <i>S. basilica</i> Cooper | Wilderness | Ridley | Tenn. | 930 |
| <i>S. basilicoidea</i> Cooper | Porterfield | Peery | Va. | 931 |
| <i>S. bellilineata</i> Cooper | Wilderness-Trenton | Oranda, Martinsburg (Salona) | Va. | 931 |
| <i>S. billingsi</i> Winchell and Schuchert | Wilderness | Chaumont-Rockland | Ontario | 932 |
| <i>S. canadensis</i> Wilson | Wilderness | Pamelia | Ontario | 932 |
| <i>S. conradi</i> Hall and Clarke | Trenton | Jacksonburg | N. J. | 933 |
| <i>S. costellata</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 933 |
| <i>S. crinerensis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 934 |
| <i>S. delicatula</i> Fenton | Wilderness | Barnhart, Plattin (Macy), Zell | Mo. | 935 |
| <i>S. dignata</i> Fenton | Wilderness | Barnhart | Mo. | 935 |
| <i>S. exigua</i> Fenton | Wilderness | Plattin (Macy), Zell | Mo. | 935 |
| <i>S. fasciculata</i> Cooper | Porterfield | Peery | Tenn. | 936 |
| <i>S. filitexta obesa</i> Wilson | Wilderness | Rockland | Ontario | 937 |
| <i>S. grandimusculosa</i> Cooper | Wilderness | Lebanon, Dryden, Ooltewah | Tenn. | 937 |
| <i>S. grandis</i> (Okulitch) | Wilderness | Lowville, Chaumont | Quebec | 938 |
| <i>S. inconsueta</i> Fenton | Wilderness | Plattin (Macy), Zell | Mo. | 938 |
| <i>S. inspeciosa</i> Willard | Wilderness | Wardell, Dryden, Mahan | Ga., Tenn., Va. | 939 |
| <i>S. magna</i> Wilson | Wilderness | Rockland | Ontario | 940 |
| <i>S. medialis</i> Butts | Wilderness | Wardell, Dryden | Tenn., Va. | 940 |
| <i>S. ? millionensis affinis</i> Wilson | Wilderness | Chaumont-Rockland | Ontario | 941 |
| <i>S. minuta</i> Wilson | Wilderness | Chaumont | Ontario | 941 |
| <i>S. mollis</i> Wilson | Wilderness | Chaumont | Ontario | 942 |
| <i>S. musculosa</i> Fenton | Trenton | Decorah (Ion) | Minn. | 942 |
| <i>S. oklahomensis</i> Cooper | Wilderness | Bromide (Pooleville) | Okla. | 942 |
| <i>S. okulitchi</i> Cooper | Wilderness | Chaumont | Quebec | 943 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

| SPECIES | | | | |
|--|------------------------|--|---------------------|------|
| Species | Stage | Formation | Geographic location | Page |
| <i>S. planobesa</i> Cooper | Porterfield-Wilderness | Murfreesboro, Ridley | Tenn. | 943 |
| <i>S. planumbona praecipta</i> Wilson | Wilderness | Chaumont | Ontario | 944 |
| <i>S. plattinensis</i> Fenton | Wilderness | Plattin (Macy), Platteville | Mo., Wis. | 945 |
| <i>S. plattinensis crassa</i> Raasch | Wilderness | Platteville | Wis. | 945 |
| <i>S. platyumbona</i> Cooper | Wilderness | Carters | Ala. | 945 |
| <i>S. rotunda</i> Wilson | Wilderness | Chaumont-Rockland | Ontario | 946 |
| <i>S. ? sculpturata</i> Bassler | Trenton | Martinsburg (base) | Pa. | 946 |
| <i>S. septata</i> Winchell and Schuchert | Trenton | Decorah (Ion) | Minn. | 946 |
| <i>S. venustula</i> Wilson | Wilderness | Chaumont-Rockland | Ontario | 946 |
| <i>Strophomena</i> sp. 1 | Wilderness | Just beneath Eureka quartzite | Nev. | 947 |
| <i>Syndielasma biseptatum</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 743 |
| <i>Taphrodonta parallela</i> Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 741 |
| <i>Taphrorthis emarginata</i> Cooper | Porterfield | Arline, Little Oak | Tenn., Ala. | 327 |
| <i>T. peculiaris</i> Cooper | Porterfield | Effna, Botetourt, Pratt Ferry, Rich Valley | Ala., Va. | 328 |
| <i>Teratelasma neumani</i> Cooper | Porterfield | Sevier | Tenn. | 824 |
| <i>Titanambonites amplus</i> (Raymond) | Porterfield | Pratt Ferry, Arline, Little Oak, Fetzner, "Lenoir" | Tenn., Ala. | 718 |
| <i>T. convexus</i> Cooper | Porterfield | Little Oak | Ala. | 719 |
| <i>T. crassus</i> (Willard) | Porterfield | Effna | Va. | 720 |
| <i>T. medius</i> Cooper | Porterfield | Athens | Tenn. | 721 |
| <i>T. praecursor</i> Cooper | Marmor | Lenoir | Tenn. | 722 |
| <i>Titanambonites</i> sp. 1 | Porterfield | "Lenoir"-Little Oak | Ala. | 723 |
| <i>Toquimia kirki</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Rhysostrophia</i> zone) | Nev. | 698 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|---|-------------|--|----------------------|------|
| <i>Torynelasma minor</i> Cooper | Porterfield | Pratt Ferry | Ala. | 257 |
| <i>T. toryniferum</i> Cooper | Porterfield | Pratt Ferry | Ala. | 258 |
| <i>Trematis elliptopora</i> Cooper | Porterfield | Pratt Ferry | Ala. | 271 |
| <i>T. foerstei</i> Cooper | Wilderness | Plattin (Macy), or Barnhart | Mo. | 271 |
| <i>T. huronensis</i> Billings | Wilderness | Black River | Lake Huron | 273 |
| <i>T. minneapolis</i> (Sardeson) | Wilderness | Decorah (Spechts Ferry) | Minn. | 273 |
| <i>T. parva</i> Cooper | Porterfield | Whitesburg, Chatham Hill | Tenn., Va. | 273 |
| <i>T. ? spinosa</i> Cooper | Porterfield | Pratt Ferry | Ala. | 274 |
| <i>Trematis</i> sp. 1 | Porterfield | Whitesburg | Tenn. | 274 |
| <i>Trematis</i> sp. 2 | Porterfield | Whitesburg | Tenn. | 274 |
| <i>Trematis</i> sp. 3 | Porterfield | Edinburg (<i>Cyrtomotella</i> zone) | Va. | 275 |
| <i>Trematorthis masoni</i> Ulrich and Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 341 |
| <i>T. robusta</i> Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 342 |
| <i>T. tenuis</i> Cooper | Whiterock | Upper Pogonip (<i>Orthidiella</i> zone) | Nev. | 342 |
| <i>Trigrammaria trigonalis</i> <i>prima</i> Wilson | Wilderness | Chaumont | Quebec | 874 |
| <i>T. wilsonae</i> Cooper | Wilderness | Rockland (Napanee) | N. Y. | 875 |
| <i>T. winchelli</i> (Hall and Clarke) | Wilderness | Platteville | Ill., Wis., Minn. | 875 |
| <i>Triplexia carinata</i> Cooper | Porterfield | Pratt Ferry | Ala. | 537 |
| <i>T. subcarinata</i> Cooper | Wilderness | Lebanon | Tenn. | 538 |
| <i>Triplexia</i> sp. 1 | Porterfield | Whitesburg | Tenn. | 539 |
| <i>Tropidothyris pentagona</i> Cooper | Porterfield | Pratt Ferry | Ala. | 507 |
| <i>Undiferina rugosa</i> Cooper | Porterfield | Pratt Ferry | Ala. | 263 |
| <i>Valcourea angulata</i> (Phleger) | Ashby | Barrel Spring | Calif. | 405 |
| <i>V. austrina</i> Cooper | Ashby | Whistle Creek, Ellett | Va. | 405 |

ANNOTATED LIST OF GENERA AND SPECIES—*Continued*

SPECIES

| Species | Stage | Formation | Geographic location | Page |
|--|----------------------|---|---------------------|------|
| <i>V. brevicarinata</i> Cooper | Porterfield | Arline | Tenn. | 406 |
| <i>V. deckeri</i> Cooper | Ashby | Tulip Creek | Okla. | 407 |
| <i>V. intracarinata</i> Ulrich and Cooper | Whiterock | Upper Pogonip | Nev. | 408 |
| <i>V. obscura</i> Cooper | Marmor | Lenoir | Tenn. | 409 |
| <i>V. plana</i> Cooper | Ashby or Porterfield | Yellow shaly ls. on 25' ss., Eureka group | Nev. | 409 |
| <i>V. semicarinata</i> Cooper | Porterfield | Arline | Va. | 410 |
| <i>V. strophomenoides</i> (Raymond) | Marmor | Crown Point | N. Y., Vt. | 411 |
| <i>V. tenuis</i> Cooper | Ashby | Tulip Creek | Okla. | 412 |
| <i>V. transversa</i> Cooper | Porterfield | Bromide (Mountain Lake) | Okla. | 413 |
| <i>V. ventro-carinata</i> (Butts) | Porterfield | Little Oak | Ala. | 414 |
| <i>Valcourea</i> sp. 1 | Ashby | Lincolnshire | Va. | 415 |
| <i>Valcourea</i> sp. 2 | Ashby | Lincolnshire | Tenn. | 415 |
| <i>Valcourea</i> sp. 3 | Porterfield | Red Knobs | Tenn. | 415 |
| <i>Valcourea</i> sp. 4 | Porterfield | Arline | Tenn. | 416 |
| <i>Valcourea</i> sp. 5 | Ashby or Porterfield | Quebec City | Quebec | 416 |
| <i>Westonia clathrata</i> (Winchell and Schuchert) | Wilderness | Decorah (Guttenburg) | Minn. | 209 |
| <i>W. superba</i> Cooper | Porterfield | Pratt Ferry | Ala. | 209 |
| <i>Westonia</i> sp. 1 | Porterfield | Whitesburg | Tenn. | 210 |
| <i>Xenambonites undosus</i> Cooper | Porterfield | Pratt Ferry | Ala. | 815 |
| <i>Zygospira circularis</i> Cooper | Wilderness | Lebanon, Carters | Tenn. | 670 |
| <i>Z. elongata</i> Cooper | Wilderness | Lebanon, Nealmont | Pa., Tenn. | 670 |
| <i>Z. lebanonensis</i> Cooper | Wilderness | Lebanon, Barnhart, Camp Nelson, Moccasin | Tenn., Mo., Ky. | 671 |
| <i>Z. ? matutina</i> Cooper | Porterfield | Little Oak | Ala. | 672 |
| <i>Z. mediocostellata</i> Cooper | Wilderness | Sevier | Tenn. | 672 |
| <i>Z. recurvirostris</i> (Hall) | Trenton | Middle Trenton | N. Y. | 673 |
| <i>Z. variabilis</i> Fenton and Fenton | Wilderness | Plattin (Macy), Zell | Mo. | 673 |
| <i>Zygospira</i> sp. 1 | Wilderness | Sevier | Tenn. | 674 |
| Gen. and sp. undet. | Porterfield | Athens, Arline, Pratt Ferry | Ala., Tenn. | 1006 |

Subclass GASTROCAULIA

Superfamily DICTYONINACEA Cooper, new superfamily

Small, transversely elliptical shells having a homoeodeltidium in pedicle valve and a broad, open or partially closed notothyrium in the brachial valve.

Family MICROMITRIDAE Schuchert, 1929

Conservative corneous brachiopods with delthyrium more or less completely closed by a homoeodeltidium.

The writer places in this family *Micromitra*, *Dictyonina*, and *Dictyonites*. The structure of these genera is very similar, and it is no longer possible to assign them to the Atremata. They cannot be assigned to the Palaeotremata because Thompson defined that order as possessing calcareous shells.

According to Bell all the genera of the Paterinidae are in need of restudy. He feels that some of them are polyphyletic, in which case family reassignments may be necessary.

Dictyonites is unusual because it is essentially a Cambrian type of brachiopod, having features that are among the earliest known in the brachiopods. The family range is thus extended to the lower part of the Middle Ordovician.

DICTYONITES Cooper, new genus

(Greek *dictyon*, a net)

Semielliptical in outline; valves hemiconical in profile, the pedicle valve forming a fairly high cone; the brachial valve, a low cone; umbonal region of both valves smooth and imperforate; remainder of valves closely perforated by large pores to form a fine meshwork (see discussion below).

Pedicle valve with moderately well formed but narrow pseudointerarea and strongly arched homoeodeltidium. Pedicle interior with short median ridge at apex. Brachial valve with narrow pseudointerarea and short, arched homoeochilidium. Traces of the musculature not seen in either valve.

Genotype.—*Dictyonites perforata* Cooper, new species.

Discussion.—Many features of this peculiar brachiopod are worthy of discussion. The general aspect of the shell allies it with the Paterinacea, and the shell itself is suggestive of the genus *Dictyonina*. It is quite unlikely that the shell was perforated through its entire substance in life. Two of the specimens indicate that an impervious outer layer was present, but its true nature cannot be ascertained from the material at hand. Evidence points to the possibility that the exterior was smooth or marked by concentric undulations. The reticulate interior reminds one strongly of the deeply punctate inner shell surface of *Iso-gramma* and *Dictyonella*.

Equally intriguing is the development of the umbonal region of both valves. This consists of imperforate shell somewhat porcellaneous in appearance forming a hemiconical apex. From the apex 2 low ridges diverge which separate 3 depressed areas. The anterior rim of the umbo is slightly protruding and from

it descends the fenestrate body of the shell. The brachial valve umbo is somewhat similarly constructed except for the fact that a median ridge divided a shallow depression on each side.

DICTYONITES PERFORATA Cooper, new species

Plate 9, D, figures 11-13; plate 10, A, figures 1-10

Shell small, semielliptical in outline with a straight hinge. Both valves hemiconical, the pedicle valve having the greater depth. Surface probably smooth or marked by concentric undulations. Inner shell layer completely and densely perforated.

Pedicle valve with narrowly rounded margins but broadly convex anterior margin; lateral profile deeply concave anterior to the umbo but flattening somewhat anteriorly; anterior profile conical with the apex of the cone surmounted by the narrowly rounded umbonal and deltidial structures and the lateral slopes steep and gently convex. Posterior margin narrowly rounded to the smooth and somewhat inclined pseudointerarea sloping upward toward the homoeodeltidium. Pseudointerarea triangular with the apex lying between the homoeodeltidium and the main shell mass, marked by indistinct horizontal lines. Homoeodeltidium strongly arched and elevated, deeply reentrant on its posterior edge and with its sides tapering along the edge of the pseudointerarea. Umbo marked by 2 diverging ridges with depressed areas separating them and the homoeodeltidium. Anterior margin of umbo defined by a slightly elevated and protruding ridge. Interior with short septum in apex.

Brachial valve forming a low half cone; lateral profile gently concave; anterior profile flat but with the umbonal region elevated; pseudointerarea very narrow; sides somewhat narrowly rounded, anterior margin broadly rounded. Homoeochilidium short, moderately strongly arched and with its sides extended along the edge of the pseudointerarea as a low ridge. Umbonal region somewhat crescentic in outline with the convex side of the crescent facing anteriorly; homoeochilidium separated from the umbo by a horizontal ridge; umbo divided by a triangular ridge with its apex pointing anteriorly; ridge bounded by depressed areas.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Paratype (pedicle valve 11683of) | 1.2 | 2.4 | 1.0 |
| " (" " 11683oa) | 1.3 | 2.3 | 1.1 |
| " (brachial valve 11683oc) | 1.3 | 2.3 | 0.5 |

Types.—Holotype: 116830-1; figured paratypes: 116830a-d,h-k; unfigured paratypes: 116830e-g.

Horizon and locality.—Lower 3 feet of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is suggestive of some of the Cambrian forms referred to *Dictyonina* or *Micromitra*, but the umbones of both valves are completely unlike any known species of these or any other genera.

Order ATREMATA Beecher, 1891

Superfamily OBOLACEA Schuchert, 1896

Family OBOLIDAE King, 1846

Obolacea with thickened and striated pedicle regions traversed by a pedicle groove. Life habits as in modern *Lingula*.

Recovery of superb corneous brachiopod material by the use of acetic acid has permitted a better understanding of some of the genera assigned to this family. It is now clear that "*Obolus*" and "*Lingula*" are composite groups consisting of many genera. Specimens recovered from the Pratt Ferry limestone of Alabama permit wider identification of *Lingulella*. The type of that genus is an Ordovician fossil, but the genus itself has been widely identified, probably correctly, in the Cambrian. A number of species herein described have the apical characters of *Lingulella* and are so assigned. A number of others are tentatively referred to this genus rather than *Lingula* because no Ordovician specimens with the beak characters of *Lingula* were seen in the material herein described.

Subfamily OBOLINAE Dall, 1870

Usually round or broadly oval forms with pedicle groove.

Genus OBOLUS Eichwald, 1829

OBOLUS ? BICONVEXA Cooper, new species

Plate 8, A, figures 1-3

Shell small, broadly oval in outline with strongly curved margins; subequally biconvex; surface marked by concentric undulations. Pedicle valve moderately convex but with the greatest convexity just anterior to the middle; anterior slope short and steep. Anterior profile of pedicle valve broadly convex and with short, steep lateral slopes and with median region swollen.

Brachial valve fairly strongly convex with the greatest convexity located in the umbonal region and its vicinity; anterior slope long and gentle; anterior profile moderately convex, somewhat narrowed medianly. Interiors unknown.

Measurements in mm.—

| | Length | Width |
|---|--------|-------|
| Holotype (pedicle valve) | 5.9 | 5.4 |
| Paratype (brachial valve 116788b) | 4.8 | 4.6 |

Types.—Holotype: 116788c; figured paratypes: 116788a,b.

Horizon and locality.—Lower Paperville formation in Tennessee: On the slope just south of the Southern RR. cut, 1 mile west of Mosheim, Mosheim (T.V.A. 181-NW) Quadrangle.

Discussion.—This species suggests *O. nitens* Cooper, new species, from a similar position in the Rich Valley in a more western belt, but differs in the lesser regularity of its ornamentation, the stronger biconvexity, and smaller size.

OBOLUS ? CYANE (Billings)

Lingula cyane BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 216, fig. 200, 1865.—
BASSLER, U. S. Nat. Mus. Bull. 92, p. 862, 1915.

Horizon and locality.—Table Head series (Logan's Division P): 4 miles northeast of Portland Creek, Newfoundland.

OBOLUS ? GRANDIS Cooper, new species

Plate 1, H, figures 26-28

Shell large and thick, suboval in outline and narrowly lenticular in profile. Lateral margins moderately curved, anterior margin subsemicircular. Valves subequally convex with the pedicle valve slightly deeper than the brachial one. Greatest convexity of both valves at about the posterior third. Surface marked by subequal concentric undulations which are a little more distinct and crowded in the posterior half than at the front.

Pedicle valve with beak missing; umbonal and midregions swollen; lateral slopes nearly flat in profile, sloping moderately to the margins. Slope from a point one-third the length from beak faintly convex.

Brachial valve with beak having an apical angle of about 120° and protruding posterior to the margin of valve junction. Midregion swollen for about two-thirds the length from the beak. Anterior slope moderately steep, flat in profile. Slopes to the lateral margins flat in profile, moderately steep.

Measurements in mm.—Holotype, length 42.7+, width 31.8, thickness 12.9.

Type.—Holotype: 71823.

Horizon and locality.—Red Knobs formation, Tennessee: In a marble quarry near Knoxville.

Discussion.—This species may be distinguished by its large size and oval form. Next to *Ectenoglossa nymphoidea* it is the largest of the linguloids known from these rocks. It differs from all other species of *Obolus* in its great size.

OBOLUS ? NITENS Cooper, new species

Plate 7, C, figures 17-19

Shell small, broadly oval in outline. Brachial valve nearly circular. Sides and anterior margin strongly rounded; posterolateral margins straight, forming a beak angle of 100° . Surface marked by strong, even, elevated, fairly closely crowded concentric lines.

Pedicle valve gently but unevenly convex in lateral profile. Strongest convexity in the umbonal region from which a long, gentle slope extends to the anterior margin. Anterior profile with low convexity but stronger than in the other view. Pedicle valve somewhat humped-up in the middle with long, moderately steep lateral slopes. Umbonal region and median two-thirds slightly swollen, most so posteriorly. Beak small and not protruding posterior to the posterior margin.

Brachial valve in lateral profile with its maximum convexity in the posterior

or umbonal region. Anterior profile slightly less convex than that of pedicle valve and not so noticeably elevated in the median region. Beak marginal and small. Umbo and posterior third slightly swollen. Posterolateral margins and anterior two-thirds somewhat flattened. Umbonal slopes short but moderately steep.

Measurements in mm.—

| | Length | Width |
|--|--------|-------|
| Holotype (brachial valve) | 8.2 | 7.6 |
| Paratype (pedicle valve 109329e) | 6.8 | 6.4 |
| “ (brachial valve 109329b) | 6.2 | 6.0 |

Types.—Holotype: 109329a; figured paratypes: 109329b,d; unfigured paratypes: 109329c,e-g.

Horizon and locality.—Lower Rich Valley formation, Porterfield Quarry in Virginia: 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species is characterized by its small size, slightly oval outline, low convexity and depth of the valves. It differs from *O. virginiensis* in its smaller size, even, concentric ornamentation without radial elements, and broader beak angle. Specimens are fairly common in the thin-bedded Rich Valley formation.

OBOLUS ? VIRGINIENSIS Cooper, new species

Plate 7, E, figures 20-22

Palaeoglossa belli WILLARD (not Billings), Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 255, 1928.

Shell large, moderately thick, oval in outline and with the greatest width located just anterior to the middle; valves unequal in depth, the brachial being the deeper. Surface marked by uneven and interrupted undulations. Umbonal region and posterolateral areas marked by transverse rows of short, elongated pustules or elevated dashes separated by short gashes. Rows of pustules extending medianly to form a low chevron.

Pedicle valve oval in outline with the greatest width located at about three-fifths the length from the beak; lateral profile slightly convex and with the maximum depth near the middle; anterior third flattened; anterior profile fullest in the median region and with short, moderately steep lateral slopes. Beak angle 95° .

Brachial valve subcircular in outline and with all margins rounded. Beak marginal; umbo and central portion of valve swollen. Lateral profile more strongly convex than that of the pedicle valve; greatest convexity in the posterior third. Posterolateral slopes moderately steep.

Measurements in mm.—

| | Length | Width |
|--|--------|-------|
| Holotype (pedicle valve) | 23.8+ | 20 + |
| Paratype (brachial valve 109335) | 18.7+ | 18.5+ |

Types.—Holotype: 109334; paratype: 109335.

Horizon and locality.—Effna limestone in Virginia: Lower part of McNutt Quarry, 5 to 6 miles northeast of Ceres, Burkes Garden (15') Quadrangle; on

road to Ceres near W. S. Waddles' house, 8 miles southwest of Bland, Bland County.

Red Knobs formation in Tennessee: Ross and Republic Quarry, 5 miles south-east of Knoxville.

Discussion.—This species is based on two specimens from calcarenite limestone at two localities. Both specimens show the chevron arrangement of the elongate pustules in the umbonal region. Although both are exfoliated, details of the interior are not clear. The species is not related to *Lingula*=*Palaeoglossa belli* to which it was originally referred. The ornamentation distinguishes this species from all other known American *Obolus*.

OBOLUS sp. 1

Plate 8, D, figures 9-11

Shell thin, of about medium size for the genus, transversely oval in outline. Greatest width located about two-thirds the length from the beak. Sides strongly rounded; anterior margin broadly rounded. Surface marked by fine, elevated concentric lines of growth.

Pedicle valve bluntly pointed, the beak forming an angle of 110° . Lateral profile very gently convex, maximum convexity located at the umbo. Anterior slope gently arched and long. Anterior profile moderately convex with flat and moderately steep lateral slopes. Umbonal and median regions swollen.

Brachial valve with outline similar to that of the pedicle valve but having a blunter and more rounded beak; greatest depth in the umbonal region. Lateral and anterior profiles gentle but similar to those of the pedicle valve.

Measurements in mm.—

| | Length | Width |
|--------------------------------|--------|-------|
| Pedicle valve (116789a) | 10.8 | 10+ |
| Brachial valve (116789c) | 10.5 | 12.0 |

Figured specimens.—116789a-c.

Horizon and locality.—Upper Table Head series, Port-au-Port, Newfoundland.

Discussion.—This is a more transverse species than any described from younger rocks.

OBOLUS sp. 2

Plate 22, F, figures 12, 13

Shell of about medium size for the genus, represented by a single brachial valve showing the interior and a counterpart thereof. Outline triangular with gently rounded sides and narrowly rounded anterolateral extremities. Anterior margin straight. Interior showing pallial marks and some of the muscle marks. Margin with fine depressions perpendicular to the shell margin; matrix along shell margin on sides and anterior with a discolored margin showing hairlike marks suggesting setae.

Measurements in mm.—Length 10.8, midwidth 8.8, widest part at front margin 10.2.

Figured specimens.—116790a,b.

Horizon and locality.—Blackford formation (shale below the “Mosheim” but above the Knox dolomite) in Virginia: About $\frac{3}{4}$ mile east of Rocky Point, Natural Bridge Special (15') Quadrangle.

OBOLUS ? sp. 3

Plate 9, F, figure 16; plate 11, A, figure 1

Fragments of a large oboloid brachiopod occur infrequently in the debris from the Pratt Ferry limestone which indicate a new species of this genus. The exterior is characterized by strong, elevated, narrowly rounded and crowded concentric lines. Not enough details of the interior are preserved to permit definite identification with *Obolus*.

Figured specimens.—116791a,b.

Horizon and locality.—Pratt Ferry limestone in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

OBOLUS ? sp. 4

Plate 9, H, figures 20-22; plate 11, D, figures 6-8

Fragments of an oboloid brachiopod taken from the residues resulting from the solution of the Pratt Ferry limestone indicate a new genus. The specimens have the usual oboloid outline, but the exterior is marked by rounded concentric ridges arranged in quincunx. Where the ridges intersect, pits are formed which are also arranged in quincunx. Inside the brachial valve is a short triangular area like that of *Obolus* formed by a fold of the shell.

Figured specimens.—116792a-c.

Horizon and locality.—Pratt Ferry limestone in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

OBOLUS ? sp. 5

Plate 2, D, figures 10, 11

This is a large species, 16.1 mm. long by 12.5 mm. wide. The single specimen is rather broadly oval in outline with the greatest width at about the middle. The greatest depth is in the posterior half. The ornamentation consists of narrowly elevated, concentric, often somewhat wavy lines. The spaces between the concentric lines are very narrow in the posterolateral slopes but widen as they cross the median part of the valve where they are distant by a space slightly more than the thickness of the concentric line. On the posteromedian region the distance between the concentric lines is greater in the posterior half than in the anterior half.

Figured specimen.—116772.

Horizon and locality.—Effna limestone in Virginia: In a pasture along Virginia State Highway 114, 11 miles east of the junction with Virginia State Highway 311 near Haymakertown, Roanoke (15') Quadrangle.

PSEUDOBOLUS Cooper, new genus(Greek *pseudes*, false)

Shells attaining a length of about an inch, oval in outline; subequally biconvex, the brachial valve having the greater convexity; pedicle beak elongated, incurved. Greatest width in anterior third. Surface marked by concentric undulations and lines of growth. Interiors delicately marked by muscular and other impressions, but none could be identified as particular scars. Muscle platforms and septa wanting.

Genotype.—*Palaeoglossa gibbosa* Willard (see below for reference).

Discussion.—It is not usually wise to propose a genus for a species that does not reveal its internal characters because of the delicacy of their preservation, but this negative fact combined with a peculiar exterior may lend value to the genus. *Pseudobolus* in its attenuated beak and strongly convex valves is exteriorly unlike *Obolus*. Furthermore, its somewhat elongate oval form is another feature unlike *Obolus*. This form suggests assignment to *Palaeoglossa*, but reference to the type of that genus shows a fairly characteristic linguloid with somewhat attenuated beak quite unlike that of the genus under discussion. Furthermore, *Lingula attenuata*, type of *Palaeoglossa*, is strongly convex but is more like *Lingula* in its outline and presumably its profiles.

Pseudobolus in exterior form is more like *Dinobolus* or *Eichwaldia*. The elongate beak and spacious, deep shells are reminders of the *Trimerellidae*, but no muscle platforms are present in either valve. *Pseudobolus* differs from *Eichwaldia* in not possessing the peculiar foramen so characteristic of that genus, and the brachial valve is nonseptate.

A word about the shell structure of *Pseudobolus* is necessary to its understanding. The shell seems to be laminated, but the lamellae are short and strongly oblique to the surface. The color is a dull whitish gray and not the usually lustrous and highly colored brown or black common to *Obolus* and closely related shells.

PSEUDOBOLUS GIBBOSUS (Willard)

Plate 24, G, figures 26-31

Palaeoglossa gibbosa WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 236, pl. 1, fig. 3, 1928.

Four specimens of this species are known besides the original type specimen. Only one is fairly well preserved; it is a young individual but shows both valves in contact. The form and beak features of this young specimen taken together with the lack of detail in the interior of the other specimens suggest a new generic stock.

The young specimen indicates a nearly equally biconvex shell with the brachial valve having the greater depth. In outline the shell is ovoid with the greatest width slightly anterior to the middle. Profile of pedicle valve gently convex; umbo well rounded, but anteriorly toward the anterior margin the shell is flattened perceptibly. Beak of pedicle valve long and slender and moderately incurved over the brachial beak.

Brachial valve more strongly convex than the pedicle valve and with the greatest convexity slightly posterior to the middle. Beak narrow and prominent; umbo swollen. Anteriorly the convexity becomes less.

Measurements in mm.—Hypotype 109422a, length 13.3, width 9.3, greatest width 10.5, thickness 5; hypotype 109422b, length 23.9, greatest width 22.1.

The proportions of the larger specimens agree with those of Dr. Willard's type specimen.

Types.—Holotype: M.C.Z. 8587; figured hypotypes: 109422a,b; unfigured hypotypes: 109422c,d.

Horizon and locality.—Murat formation in Virginia: 2 miles northwest of Lexington, Lexington (15') Quadrangle.

PSEUDOBOLUS sp. 1

A single valve of another species occurs in the collection. The specimen is subtriangular in outline, chalky grayish white in color. The surface is smooth except for 4 deep concentric grooves representing resting stages of growth. Greatest width in anterior third. The lateral profile is moderately convex with the greatest curvature at the umbo. Anterior profile is broadly convex with a flattened median region and short but steep lateral slopes.

Measurements in mm.—Length 15.6, midwidth 12.5, greatest width 16.

Described specimen.—109421.

Horizon and locality.—Effna formation in Virginia: In the lower part of the McNutt Quarry, 12 miles south of Bland, Burkes Garden (15') Quadrangle.

Discussion.—This species differs from adult *P. gibbosus* by its plaited exterior and more attenuate form.

Subfamily LINGULELLINAE Schuchert, 1893

Elongate and narrowly oval oboloids with pedicle groove; brachial valve with concave, transversely striated apical plate.

Until recently it has not been possible to distinguish the true generic characters of most of the early and middle Ordovician linguloids. The etched material from Pratt Ferry has permitted a good look at the hinge structures, but the muscle arrangements are still to be worked out. The type species of *Lingulella* comes from the Ordovician. Most of the species referred here to *Lingulella* have not revealed their hinge structures. It is believed to be sounder to refer all these to *Lingulella*, which is an Ordovician genus, rather than to call them *Lingula*, which is a recent genus.

Genus LINGULELLA Salter, 1866

LINGULELLA ALABAMENSIS Cooper, new species

Plate 8, E, figures 12, 13

Shell small for the genus, brown to yellow-brown in color, widely oval in outline and with the greatest shell width anterior to the middle. Pedicle valve with

an apical angle of 70° to 80° ; posterolateral margins straight; lateral margins moderately strongly curved and gradually passing into the broadly curved anterior margin. Surface of both valves marked by elevated concentric lines crowded on the lateral margins but more distant where they swing over the median parts of the valves.

Pedicle valve with lateral profile gently convex and with maximum depth slightly posterior to the middle; anterior slope long and gentle; anterior profile fairly strongly convex.

Brachial valve less acuminate at the beak than the pedicle valve and with gently rounded lateral margins; lateral profile flat medianly but with nearly equal and gentle anterior and posterior slopes occupying the anterior and posterior quarters. Umbonal and median regions somewhat swollen. Anterior profile broadly curved.

Interior of pedicle valve with blisterlike, elongate triangular folds inside the beak, the folds bounding a deep pedicle groove. Brachial valve with thickened posterior margin and deep umbonal cavity and a long, low median ridge extending to about the middle.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (brachial valve) | 8.9 | 6.6 | ? |
| Paratype (pedicle valve 109309a) | 10.7 | 7.6 | 1.0 ? |
| “ (“ “ 109309b) | 11.2 | 8.4 | ? |

Types.—Holotype: 109309d; figured paratype: 109309b; unfigured paratypes: 109309a,c.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—*Lingulella alabamensis* is characterized by having a widely oval outline and somewhat attenuated beaks. It differs from *L. lirata*, which it resembles, in its wider anterior region and more narrowly pointed beaks.

LINGULELLA BRAINERDI (Raymond)

Plate 3, D, figures 8-12

Lingula brainerdi RAYMOND, Bull. Amer. Paleont., vol. 3, p. 36, pl. 18, figs. 2, 3, 1902; Ann. Carnegie Mus., vol. 7, No. 2, p. 217, pl. 33, fig. 2, 1911.

Lingula limitaris SEELY (nom. nud.), Rep. State Geol. Vermont, n. s., vol. 1, p. 145, 1902; vol. 5, p. 183, pl. 41, 1906.

Shell of moderate size for the genus, longer than wide; outline subpentagonal; apical angle about 90° ; lateral margins gently curved to nearly straight and forming shoulders with the posterolateral margins. Anterolateral extremities narrowly rounded to subangular; anterior margin gently rounded. Greatest width located between the anterolateral angles and the posterolateral shoulders. Ornamentation consisting of fine concentric growth lines and stronger, more distant concentric undulations.

Pedicle valve gently convex in lateral profile with the greatest convexity about one-third the length anterior to the beak. Valve full in the midregion but slop-

ing gently to the anterior margin; anterior third flattened; slopes to lateral margins fairly steep in the posterior third but becoming gentle in the anterior third.

Brachial valve rounder in outline than the pedicle valve. Moderately convex in lateral profile; fairly strongly rounded in anterior profile; posterior margin obtuse, rounded, having an apical angle of about 110° . Beak blunt, reaching the margin; umbo somewhat swollen; valve full for two-thirds the distance from beak; lateral slopes moderately steep.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Hypotype (pedicle valve 109277a) | 21.4 | 13.9 | ? |
| " (" " 109277b) | 20.7 | 14.5 | ? |
| " (" " 109277c) | 18.1 | 12.6 | 1.5 |
| " (" " 109277d) | 18.8 | 14.4 | ? |
| " (brachial valve 109277e) | 14.8 | 10.0 | ? |
| " (" " 109277f) | 16.8 | 12.1 | 2.0 |
| " (" " 109277g) | 17.3 | 12.0 | ? |

Types.—Cotypes: Cornell Univ.; hypotype: Carnegie Mus. 5432; figured hypotypes: 109277a,c,f,g; unfigured hypotypes: 109277b,d,e.

Horizon and locality.—Lower sandstone of the Chazy group in New York: At Valcour Island, and Crown Point, Plattsburg (15') Quadrangle. In Vermont: On South Hero and Isle La Motte, Rouses Point (15') Quadrangle.

Discussion.—This species is characterized by its subpentagonal outline with greatest width near the anterior margin and the gently curved anterior margin. The latter feature gives the valves an appearance of possessing a truncated anterior, but in fact it is broadly curved.

An attempt was made to determine internal features by dissolving the shell away from its matrix. Although some good impressions of the exterior were obtained, the internal features are not sufficiently distinct or well-enough preserved to leave traces on the sandstone. Fine radial lines appear on the inside of exfoliated specimens of both valves and the casts of interiors. Such lines are common in many linguloid shells and may be the impressions of setae.

A few immature specimens indicate that *L. brainerdi* is a somewhat longer and more slender shell in its early maturity. The valves at that time are proportionately longer and the outline more rounded and elliptical. The greatest width remains in the anterior third, but it is by no means so pronounced as in the older shells.

Lingulella brainerdi differs from *L. huronensis* Billings in its proportions, the location of the greatest width near the front rather than near the middle, and in having the greater height in the posterior third. *Pseudolingula luttrellensis* Cooper, new species, has a pentagonal form similar to that of *L. brainerdi* but is proportionally wider and has a much flatter shell.

LINGULELLA ? CLOCHENSIS (Foerste)

Lingula clochensis FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 17, p. 253, pl. 2, figs. 11a, 11b, 1914.

Types.—Holotype: G.S.C. 8403; paratype: G.S.C. 8403a.

Horizon and locality.—"Lowville" formation, La Cloche Peninsula, Ontario.

LINGULELLA COLUMBA (Raymond)

Lingula columba RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 368, 1905; Ann. Carnegie Mus., vol. 7, No. 2, p. 218, pl. 33, figs. 3, 4, 1911.

Horizon and locality.—Chazy limestone, Valcour Island and Chazy, Plattsburg (15') Quadrangle, N. Y.; and Isle La Motte, Rouses Point (15') Quadrangle, Vt.

LINGULELLA DECORTICATA Cooper, new species

Plate 9, E, figures 14, 15

Shell thin, small for the genus; length about $1\frac{1}{2}$ times the width; sides gently convex, subparallel; anterior margin broadly rounded; anterolateral extremities narrowly rounded; apical angle about 85° ; posterolateral margins nearly straight and forming indistinct shoulders at about one-fifth the length from the beak. Greatest width at about the middle. Surface marked by fine, crowded concentric lines.

Pedicle valve with fairly evenly but gently convex lateral profile; umbonal region slightly the more convex part of the valve; anterior slope long and gentle; anterior profile moderately convex.

Brachial valve slightly more convex than the pedicle valve and with broadly rounded posterior margin. Beak small, protruding slightly posterior to the margin; lateral profile most convex at about the middle; anterior profile more convex than that of the pedicle valve; somewhat swollen in the medial region with moderately long and steep lateral slopes.

Measurements in mm.—Length 11.2, width 7.3.

Type.—Holotype: 116757.

Horizon and locality.—Elway formation in Virginia: $\frac{1}{4}$ mile east of Belfast Mill, Saltville (T.V.A. 212-NE) Quadrangle.

Discussion.—This species differs from *L. livata* in having a less attenuated posterior.

LINGULELLA ENDOPUNCTATA Cooper, new species

Plate 8, G, figures 15, 16

Shell small for the genus, lustrous dark brown to black in color; longitudinally elliptical in outline with rounded lateral margins, narrowly rounded anterior and bluntly pointed posterior extremities. Brachial valve deepest slightly posterior to the middle, with a moderately steep and short posterior slope but with a longer, convex but gentle anterior slope. Moderately strongly convex in anterior profile; umbonal region swollen; median region full; lateral slopes moderately steep. Median elevation indistinct but present. Pedicle valves too poorly preserved for description. Surface poorly preserved but the ornamentation consisting of more or less distant concentric undulations.

Measurements in mm.—Holotype, length 7.3, width 4.5.

Types.—Holotype: 109320b; figured paratype: 109320a; unfigured paratypes: 109320c-e.

Horizon and locality.—Botetourt formation (*Cybeloides* bed) in Virginia: $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Discussion.—This small species is characterized by its lustrous black color, strong convexity, and narrowly oval form. It suggests *Elliptoglossa* in outline but is much more convex. It is not close to any other described Ordovician species of *Lingulella*.

LINGULELLA FOSTERMONTENSIS (Butts)

Plate 1, E, figures 13-18; plate 10, D, figures 18-22

Lingula fostermontensis BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 108, pl. 22, figs. 11, 12, 1926.

Shell of medium size for the genus, subpentagonal to elongate oval in outline; longer than wide with the greatest width at about the middle. Valves nearly equal in depth; lateral margins subparallel; anterolateral extremities strongly rounded; anterior margin only moderately rounded. Posterolateral and lateral margins forming a distinct shoulder, particularly in young specimens. Color dark brown. Surface marked by irregularly spaced concentric undulations crossed by fine concentric wavy lines.

Pedicle valve with beak missing in all specimens; gently convex in lateral profile but moderately convex in anterior profile. Full in midregion for two-thirds the length and with moderately steep slopes at the posterior becoming gentler anteriorly. Front third flattened.

Brachial valve having posterolateral shoulders prominent, flattened; umbonal region swollen but merging into the flattened front third. Lateral slopes steep and abrupt to the flattened areas defining the shoulders. Beak protruding slightly posterior to the posterior margin. Anterior slope gentle.

Measurements in mm.—

| | Length | Width | Thickness |
|---------------------------------------|--------|-------|-----------|
| Lectotype (brachial valve) | 12.3 | 8.9 | 1.5 |
| Paratype (pedicle valve 71490a) | 13.0+ | 8.9 | 1.5 |
| Hypotype (" " 116759a) | 20.8 | 11.2 | 1.7 |
| " (brachial valve 116759b) | 18.5 | 10.8 | 1.3 |

Types.—Lectotype: 71490b; paratype: 71490a; figured hypotypes: 109284d, 116759a-c; unfigured hypotypes: 109284a-c,e-f, 116759d-f.

Horizon and locality.—Attalla formation (Blackford facies), Alabama: West base of Foster Mountain, 1 $\frac{1}{4}$ miles northwest of Clay, Jefferson County, Leeds (15') Quadrangle.

Discussion.—This species is characterized by its solid form, fairly prominent posterolateral shoulders, strong concentric undulations covered by fine concentric but wavy lines. In shape it suggests *Lingulella brainerdi* Raymond and *Pseudolingula luttrellensis* Cooper, new species, but both of these have less distinct shoulders on the brachial valve.

LINGULELLA GALBA Cooper, new species

Plate 7, B, figures 13-16

Color orange-yellow; valves oval in outline with the greatest width slightly anterior to the middle. Lateral margins gently rounded. Anterolateral and anterior margins forming a semicircle. Beak of pedicle valve acute, apical angle, about 70° . Surface of both valves marked by concentric undulations crowded at the margins but more spread-out in the median region.

Pedicle valve: Lateral profile gently convex; anterior profile moderately convex. Umbonal region narrowly rounded and with steep slopes to the margins.

Brachial valve: Both profiles gently convex and having greater convexity than the pedicle ones. Midregion moderately swollen; anterior slope gentle; slopes to lateral margins moderate.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 12.0 | 8.5 | 1.3 |
| Paratype (brachial valve 109282a) | 10.4 | 8.2 | 1.8 |

Types.—Holotype: 109282b; figured paratype: 109282a; unfigured paratypes: 109282c-g.

Horizon and locality.—Bromide formation (Mountain Lake member), in Oklahoma: Middle of east line sec. 33, T. 2 S., R. 2 E., 2 miles east of Springer, Carter County.

Discussion.—This species suggests the exfoliated *Spinilingula intralamellata* Cooper, new species, but that is a much smaller species with stronger and more distant concentric lamellae, and external spines.

LINGULELLA ? GLYPTA Cooper, new species

Plate 1, G, figures 21-25

Represented by two specimens of longitudinally elliptical outline; brachial valve slightly deeper than the pedicle valve. Color light grayish brown. Sides subparallel, gently curved. Anterior margin narrowly rounded. Median and lateral areas differently sculptured, the former by irregular concentric undulations which disappear on the flanks. Sides marked by striae closely crowded on the lateral slopes near the margins but extending obliquely over the concentric undulations on the lateral slopes near the junction with the median region.

Pedicle beak broken; lateral profile gently convex with the most elevated part at about the middle; anterior profile more strongly convex and with moderately steep lateral slopes. Brachial valve with moderately convex lateral profile, with the greatest convexity slightly posterior to the middle; posterior slope short and moderately steep; anterior slope long and gentle. Anterior profile moderately convex and with moderately steep lateral slopes. Incomplete dimensions in mm. of holotype: length 11, width 6.5, thickness 2.9.

Types.—Holotype: 116760a; figured paratype: 116760b.

Horizon and locality.—Bromide formation (Pooleville member-zone 3) in

Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—This species is characterized by the crowding of striae along the sides and its long slender form. It differs from *L. lirata* Cooper, new species, in its laterally confined striate ornamentation.

LINGULELLA HURONENSIS (Billings)

Lingula huronensis BILLINGS, Canadian Nat. Geol., vol. 4, p. 433, fig. 9, 1859; Geol. Canada, p. 124, fig. 48, 1863.—RAYMOND, Ann. Carnegie Mus., vol. 7, p. 219, 1911.—SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 69, pl. 4, figs. 1-3, 1945.—WILSON, Geol. Surv. Canada, Bull. 8, p. 19, pl. 1, figs. 14, 15, 1946.

Types.—Lectotype: G.S.C. 1159; paratype: G.S.C. 1159a.

Horizon and locality.—Black River, St. Joseph Island, Lake Huron.

LINGULELLA ? HURONENSIS MINGANENSIS (Twenhofel and Whiting)

Lingula huronensis BILLINGS, Canadian Nat. Geol., vol. 4, p. 433, fig. 9, 1859.

L. huronensis minganensis TWENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 44, pl. 7, fig. 15, 1938.

Type.—Holotype in Twenhofel Collection.

Horizon and locality.—Basal Mingan formation, Mingan Islands, St. Lawrence River.

LINGULELLA KINGSTONENSIS (Billings)

Lingula kingstonensis BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 48, fig. 51 (adv. sheets, 1862), 1865; Geol. Canada, p. 141, fig. 74, 1863.

Types.—Lectotype (G. W. Sinclair, 1945): G.S.C. 1158; paratypes: G.S.C. 1158a-c,e,f.

Horizon and locality.—Black River formation, near Long Island, near Kingston, Ontario, Canada.

LINGULELLA LIRATA Cooper, new species

Plate 2, C, figures 8, 9; plate 5, H, figures 20-25; plate 6, D, figures 16, 17; plate 11, B, figures 2-4; plate 28, F, figures 17-23

Lingula lyelli WILLARD (not Billings), Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 256, pl. 1, fig. 2, 1928.

Elongate oval in outline, length slightly less than twice the width; lateral margins very slightly convex and forming small shoulders where they join the posterolateral margins. Beak forming an angle of about 80°. Surface marked by fine elevated concentric lines which are crowded and prominent in the lateral and posterolateral regions on the lateral slopes but indistinct on the median part of the shell. Median region appearing smooth.

Pedicle valve deepest at a point about one-third the length from the beak; anterior slope long and gentle; umbonal region narrowly swollen, the swelling extending for the whole length but becoming gentler anteriorly; anterior profile moderately strongly convex. Posterolateral slopes short and steep.

Brachial valve with narrowly rounded posterior and anterior margins; deepest in the posterior third and with a long, gently convex anterior slope. Anterior profile low and gently rounded. Median region from beak to anterior margin gently swollen; lateral slopes short and moderately steep.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype | 16.3 | 8.4 | 3.0 |
| Paratype (pedicle valve 109332a) | 12.0 | 6.6 | ? |
| “ (“ “ 117975b) | 10.9 | 6.5 | 1.8 |
| “ (brachial valve 109332c) | 10.0 | 5.9 | ? |
| “ (“ “ 109317b) | 16.0 | 9.3 | 4.4 |
| “ (“ “ 117980) | 9.2 | 6.2 | 1.5 |

Types.—Holotype: 109317a; figured paratypes: 109317b, 109332a,b, 116761a,b, 117975a-c, 117980; unfigured paratypes: 109332c,d, 116761a,b, 117975d.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 miles south of Pratt Ferry, Blocton (15') Quadrangle.

Whitesburg formation in Tennessee: 2 miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: 1 mile northwest of Lexington, Lexington (15') Quadrangle.

Effna formation in Virginia: McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Discussion.—This species is characterized by its moderate size, elongate-oval outline, subparallel sides, and acutely angular beak. It is larger than *L. decorticata*, new species, and with more parallel sides. Its elongate form distinguishes it from *L. galba*, new species.

LINGULELLA MORSEI (N. H. Winchell)

Lingulepis morsensis N. H. WINCHELL, 4th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 41, fig. 6, 1876.

Lingula morsei (N. H. Winchell) BASSLER, U. S. Nat. Mus. Bull. 92, p. 731, 1915.

Horizon and locality.—Upper part of the St. Peter sandstone in Minnesota: Near Fountain, Fillmore County.

LINGULELLA NARRAWAYI (Wilson)

Lingula narrawayi WILSON, Geol. Surv. Canada, Bull. 33, p. 49, pl. 3, figs. 4-6, 1921; idem, Bull. 8, p. 19, pl. 1, figs. 10, 11, 1946.

Type.—Holotype in Royal Ontario Museum, Toronto.

Horizon and locality.—Lowville formation, Parkdale Avenue, Ottawa, Canada; also reported from Pamela formation at Aylmer and Hull in Quebec and at Ottawa, Ontario.

LINGULELLA RIDEAUENSIS Cooper, new species

Plate 5, I, figures 26-31

Shell thin, of about medium size for the genus, oval in outline, dark brown or black in color. Beak pointed, posterolateral margins straight and forming an angle of about 90° with the beak. Widest slightly anterior to the middle. Lateral margins broadly rounded; anterior margin gently rounded, forming narrowly rounded anterolateral extremities. Valves subequal in depth. Surface marked by unevenly spaced, elevated concentric lines crowded in the posterolateral regions, more distant in the median area.

Pedicle valve unequally convex with the maximum depth at about the middle; anterior slope long and gentle; umbonal and median regions swollen; lateral slopes moderately steep, short, extending anteriorly nearly to the anterolateral margins.

Brachial valve swollen in the umbonal and median regions, the swelling extending anteriorly to a point anterior to the middle; lateral profile strongly elevated in the median half, sloping in the posterior and anterior quarters; anterior slope short but fairly gentle. Anterior and posterior profiles broadly rounded in the median region with short, moderately steep lateral slopes. Beak bluntly pointed, not protruding posterior to the posterior margin.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|--------|-----------|
| Holotype (pedicle valve) | 13.5+ | 10.6 | 1.0 ? |
| Paratype (brachial valve 109315a) | 15.6 | 12.0 ? | 1.6 ? |

Types.—Holotype: 109315c; figured paratypes: 109315a,b, 109324a,c; unfigured paratypes: 109324b.

Horizon and locality.—Aylmer formation (Rockcliffe member) in Canada: Hogs Back on Rideau River south of Ottawa, Gloucester Township, Carleton County, Ontario; $4\frac{1}{2}$ miles west of Ottawa, Ontario.

Discussion.—This species is characterized by its thin shell, oval outline, and exterior marked by concentric undulations only. It suggests *L. brainerdi*, but that species generally attains a larger size than the Canadian species and is more quadrate in outline. *Lingulella? huronensis* is of about the same size but is less attenuated.

LINGULELLA RUGOSILINEA Cooper, new species

Plate 4, D, figures 14-16

Shell small, longer than wide, ovate in outline with gently convex lateral margins. Anterior margin gently rounded; anterolateral extremities broadly rounded. Pedicle beak bluntly pointed, forming an angle of about 100° . Beak of brachial valve marginal, forming an angle of about 110° . Surface ornamented by fine irregular radial striae between which are located fine concentric wrinkles concave posteriorly and ending laterally against the striae. Radii lost near the margins where wavy concentric lines make the ornament.

Measurements in mm.—Holotype, length 12.5, width 7.3.

Types.—Holotype: 45069a and counterpart 45069b; figured paratype: 45069c.

Horizon and locality.—Aylmer formation (Rockcliffe member, black shale) in Canada: Hogs Back, south of Ottawa, Gloucester Township, Carleton County, Ontario.

Discussion.—The ornamentation of this species is like that of *Pseudolingula sculptata* from the Camp Nelson formation at High Bridge, Ky., but the latter is a much larger species with relatively finer ornamentation.

LINGULELLA SPICATA Cooper, new species

Plate 7, D, figures 23, 24

Shell of small to medium size for the genus, brownish gray to dark brown in color; length $1\frac{1}{2}$ times the width, narrowly oval in outline with a strongly pointed beak and broadly expanded anterior. Apical angle about 60° . Lateral margins gently curved from the beak to the anterolateral margins which are narrowly rounded; anterior margin strongly curved. Surface marked by strong concentric, elevated lines, crowded along the margins but not strongly elevated, faint on the median areas.

Pedicle valve: Lateral profile gently convex with the greatest depth at about the middle and with long, gentle anterior and posterior slopes. Posterior profile narrowly rounded; anterior profile only gently rounded. Umbonal region narrowly convex and with steep lateral slopes, the swelling continuing anteriorly to a point slightly anterior to the middle; anterior third flattened.

Brachial valve: Brachial convexity about equal to that of the pedicle valve but with the maximum depth slightly posterior to the middle; anterior profile moderately convex, distinctly more so than that of the pedicle valve; posterior profile less convex than that of the opposite valve; anterior slope gently convex, long and moderately steep. Posterior margin narrowly rounded and with the beak anterior to the posterior margin. Lateral margins very gently curved; anterolateral extremities narrowly rounded; anterior margin strongly curved. Umbonal and median areas moderately strongly swollen.

Measurements in mm.—

| | Length | Width |
|---|--------|-------|
| Holotype (pedicle valve) | 15.0 | 9.8 |
| Paratype (brachial valve 109301b) | 10.5 | 7.4 |

Types.—Holotype: 109301a; figured paratype: 109301b; unfigured paratypes: 109301c,d.

Horizon and locality.—Whitesburg formation in Tennessee: Railroad cut at Summit Hill School, 1 mile southwest of Otes, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Discussion.—This species is characterized by the strongly acuminate pedicle beak, in which respect it is reminiscent of the Cambrian *Lingulepis*. This species is different from all others herein described in the acuminate character of the beak.

LINGULELLA SUBPARALLELA Cooper, new species

Plate 4, B, figures 5-8

Shell small, longitudinally narrowly elliptical; lateral margins faintly rounded, nearly parallel; anterior margin narrowly rounded. Beak of pedicle valve forming approximately a right angle. Posterior margin of brachial valve narrowly rounded. Surface marked by strong and irregular concentric undulations and covered by very fine concentric, wavy lines.

Valves of unequal depth, the brachial valve having a slightly greater depth than the pedicle valve. Valves deepest at the posterior but becoming shallower toward the front. Lateral slopes moderately steep at the posterior and median part of both valves but merging into the flattened anterior part.

Measurements in mm.—Holotype, length 7.5, width 2.8, thickness 1.5.

Type.—Holotype: 109295.

Horizon and locality.—Effna formation in Virginia: 1 mile east of Tilson Mill, 16 miles northeast of Marion, Nebo (T.V.A. 223-NW) Quadrangle.

Discussion.—This interesting little species suggests *Lingula clathrata* Winchell and Schuchert from the Decorah shale of Minnesota, but the Virginia shell differs in its larger size and more elongate form, and in not possessing the peculiar ornamentation of the Minnesota species which is referred to as *Westonia*.

LINGULELLA TENUITESTA Cooper, new species

Plate 1, F, figures 19, 20

Shell small, dark brown in color, oval in outline, biconvex, with thin shell. Posterolateral margins nearly straight; lateral margins convex; widest at middle; anterior margin gently convex. Beak of pedicle valve pointed, forming an angle of 80°. Ornamentation consisting of very fine, closely crowded, elevated concentric lines, often irregular and discontinuous.

Pedicle valve gently convex in anterior and lateral profiles. Lateral profile uneven with the greatest elevation slightly posterior to the middle; anterior profile broadly and somewhat depressed convex. Beak bluntly pointed; umbonal region somewhat narrowly swollen. Posterolateral slopes moderately steep, median slopes gentler than the posterolateral ones. Anterior slope long and gentle.

Brachial valve with anterior and lateral profiles depressed convex. Lateral slopes narrow and moderately steep; anterior slope long and gentle. Maximum convexity of valve at about the middle which is somewhat flattened.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (pedicle valve) | 8.1 | 6.3 | ? |
| Paratype (pedicle valve 109299c) | 9.8 | 6.6 | ? |
| “ (brachial valve 109299b) | 6.2+ | 5.5 | ? |

Types.—Holotype: 109299a; figured paratype: 109299b; unfigured paratypes: 109299c, 109300a-j.

Horizon and locality.—Columbiana formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—Small size and thin shell are the characteristics of this species. It differs from *L. lirata* Cooper, new species, from the Pratt Ferry formation from the same locality in size and shape.

LINGULELLA VIRGINIENSIS Cooper, new species

Plate 1, C, figures 4, 5

Shell small, yellowish brown in color, subovate in outline. Beak approximately a right angle; lateral margins rounded; anterior margin narrowly rounded. Valves unequally convex, the brachial one having the greater convexity. Surface ornamented by a few distant concentric lines and finer lines of growth.

Pedicle valve nearly flat in lateral profile but gently convex in anterior profile. Slopes to the lateral margins steep at the posterior but becoming obsolete anteriorly.

Brachial valve gently convex with the greatest convexity located slightly posterior to the middle. Lateral slopes steep posteriorly where the valve is somewhat swollen medially, but becoming gentle anteriorly. Beak blunter than pedicle one.

Measurements in mm.—Holotype (pedicle valve), length 6.8, brachial length 6.5, width 4.0, thickness of complete specimen 1.6.

Type.—Holotype: 109296.

Horizon and locality.—"Ottosee formation" (probably Benbolt) in Virginia: 1 mile west of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—The ornamentation will serve to distinguish this species before any of its other features. The distant concentric lines are like those of *Plectoglossa oklahomensis*, but this is a smaller and narrower species.

LINGULELLA sp. 1

Plate 8, C, figures 6-8

Black in color, narrowly elliptical in outline, length twice the width; greatest width at about the middle. Lateral margins gently curved, anterior and posterior extremities rounded. Ornamentation poorly preserved. Brachial valve deepest in the middle with long posterior and anterior slopes, the latter being the steeper. Anterior and posterior profiles narrowly convex with steep lateral slopes.

Measurements in mm.—Length 18.3, width 8.9, thickness 2.4?

Figured specimens.—116769a,c.

Horizon and locality.—Dark limestone of Upper Pogonip group (*Anomalorthis* zone) in Nevada: Ikes Canyon, east side of Toquima Range, Roberts Mountains (1°) Quadrangle.

LINGULELLA sp. 2

Plate 5, B, figure 6

Shell large for the genus, as shown by a single brachial valve; elongate oval in outline, length about $1\frac{2}{3}$ times the width. Maximum width slightly anterior

to the middle. Posterior bluntly pointed; lateral margins broadly rounded but with a strongly rounded anterior margin. Gently convex in anterior and lateral profile. Surface preserved in the posterolateral region where it is marked by regular, fine, elevated concentric lines.

Measurements in mm.—Length 27.1, width 15.6, thickness 1.5?

Figured specimen.—116771.

Horizon and locality.—Oil Creek formation (60 feet above the basal sand) in Oklahoma: Sec. 12, T. 3 S., R. 3 E., $1\frac{3}{4}$ miles northwest of Sylvan, Carter County.

LINGULELLA ? sp. 3

Plate 8, H, figures 17, 18

Represented by a single brachial valve which is large for the genus, oval in outline with the length about $1\frac{1}{2}$ times the width. Beak prominent, narrowly elevated and protruding posterior to the posterior margin which is somewhat broadly rounded. Ornamentation consisting of fine, crowded, faintly elevated lines shown in 2 small patches preserved at the posterior on both sides of the beak. Evidence of an elongated central muscle track is indicated on the exfoliated specimen.

Measurements in mm.—Length 22.6, width 15.8.

Figured specimen.—109312.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile south of Newala, Montevallo (15') Quadrangle.

LINGULELLA ? sp. 4

Plate 5, A, figures 1-5

Fairly large for the genus, elongate elliptical in outline with nearly parallel sides; valves subequally biconvex; length twice the width. Surfaces badly exfoliated but a patch showing the exterior indicates elevated concentric lines as the surface ornament. Brachial valve showing indications of a median ridge extending nearly the full length.

Measurements in mm.—Length 16.3 (not complete), width 8.3, thickness 4.0.

Figured specimen.—109304.

Horizon and locality.—Arline formation (middle to upper) in Tennessee: On Sevierville Pike, 5 miles southeast of Knoxville, Knoxville (T.V.A. 147-NW) Quadrangle.

LINGULELLA ? sp. 5

Plate 5, C, figures 7, 8

This also is an elongate species which measures 14.3 mm. in length by 7.7 mm. in width. It may be related to or the same as *Lingulella* sp. 4 but seems a deeper shell. The brachial valve is moderately deep and moderately convex in lateral profile but is fairly strongly convex in anterior view. The surface is marked by fairly regular concentric elevated lines, finer and more crowded on the sides than on the median portion of the shell.

Figured specimen.—109307a.

Horizon and locality.—Arline formation in Tennessee: North side of wagon road in glade, $\frac{1}{4}$ mile east of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

LINGULELLA sp. 6

Plate 2, B, figures 6, 7

About medium size for the genus, length about $1\frac{1}{2}$ times the width; sides gently curved, subparallel; anterior margin broadly curved; anterolateral extremities somewhat narrowly curved; posterior margin forming an angle of about 110° . Beak anterior to posterior margin. Surface with concentric, elevated growth lines crowded on the posterolateral extremities but more distant and somewhat more regularly spaced on the median region. Specimens somewhat crushed, making it impossible to describe the profiles accurately. The two specimens available are brachial valves.

Figured specimen.—109322.

Horizon and locality.—Aylmer formation (Rockcliffe member) in Canada: Aylmer, Province of Quebec.

LINGULELLA sp. 7

Plate 8, F, figure 14

Shell small for genus, shiny brown in color, represented by the pedicle valve only. Outline oval, posterior end acutely angular, apical angle about 80° . Lateral margins gently curved; anterior margin strongly and broadly curved; lateral profile gently convex but with anterior and posterior profiles fairly strongly convex. Umbonal region strongly convex with steep lateral slopes. Anterior slope long and gentle, forming a broad depressed area in the anterior third. Greatest width anterior to the middle. Surface marked by fine, elevated concentric lines crowded along the sides but often indistinct on the median region.

Measurements in mm.—Length 5.9, width 4.3.

Figured specimen.—109298.

Horizon and locality.—Dutchtown formation in Missouri: Geiser Quarry, $1\frac{1}{2}$ miles east of Dutchtown, Cape Girardeau (15') Quadrangle.

LINGULELLA ? sp. 8

Plate 9, B, figures 7, 8

Shell small, narrowly oval in outline and with the narrowest part at the posterior; anterior narrowly rounded; surface marked by distant, elevated corrugations. Interior with a median callosity.

Figured specimen.—116779.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Genus WESTONIA Walcott, 1901

WESTONIA CLATHRATA (Winchell and Schuchert)

Plate I, A, figures 1, 2

Lingula clathrata WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 345, pl. 29, fig. 42, 1893.

Shell small, thin, longitudinally elliptical in outline. Lateral margins broadly rounded; anterior margin narrowly rounded. Greatest width at the middle or slightly anterior to the middle. Beak angle about 90°. Surface marked by strong concentric undulations which are crossed by transverse, subparallel lines that swing slightly posteriorly at the middle to form a broad and shallow V. Transverse lines most prominent on the flanks and body of the shell in the posterior two-thirds, the anterior third being marked by such lines only on the lateral slopes.

Pedicle valve with umbonal and median region somewhat swollen; greatest depth in the posterior third; anterior slope long and gentle; umbonal slopes short and steep. Anterior profile gently convex.

Brachial valve somewhat more convex than the pedicle one in both profiles. Lateral profile gently convex but anterior profile moderately arched; beak marginal; lateral slopes fairly strong; anterior slope gentle.

Measurements in mm.—

| | Length | Width |
|---------------------------------------|--------|-------|
| Lectotype (brachial valve) | 3.6 | 2.0 |
| Paratype (pedicle valve 45546a) | 4.5 | 2.3+ |

Types.—Lectotype: 45546b; figured paratype: 45546a; unfigured paratypes: 45546c-l.

Horizon and locality.—Decorah formation (Guttenberg member-*Rhinidictya* bed) in Minnesota: At St. Paul.

Discussion.—This species is characterized by its small size and peculiar ornamentation. The transverse lines are fairly distant, about 4 to the millimeter on the shell edge, and crowding only slightly medially. The posterior swing in the lines is shallow and separates this species easily from the others here assigned to this genus.

Details of the interior are so difficult to determine from the specimens available that it is not possible to decide the type of hinge region in the two valves.

WESTONIA SUPERBA Cooper, new species

Plate II, E, figures 9, 10

Shell of about medium size for the genus, known from the brachial valve only. Elongate, oval in outline, sides diverging anteriorly, nearly straight; anterior margin narrowly rounded. Beak and umbo smooth; remainder of valve marked by concentric, narrowly rounded, low costellae, nearly parallel on the margins but swinging posteriorly to form a quincunxial pattern on the median region. Strongly convex medially with long and moderately steep lateral slopes. Interior

like that of *Lingulella*. The largest specimen is incomplete but measures 6.5 mm. in length and 5.2 mm. at its widest part.

Type.—Holotype: 116780b; unfigured paratypes: 116780a,c,d.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

WESTONIA sp. 1

Plate 1, B, figure 3

Specimen incomplete, consisting of the posterior two-thirds of a brachial valve with swollen median and umbonal regions and gently curved lateral margins. Posterior profile somewhat narrowly convex and with fairly steep lateral slopes. Surface, particularly the median region, marked by transverse regular undulations forming a moderately deep V or chevron directed posteriorly in the median region. The chevrons are cancellated by strong concentric undulations which give the valve a pitted appearance in places.

Figured specimen.—116781a.

Horizon and locality.—Lower part of Whitesburg formation in Tennessee: Just above the Fetzner formation, on the slope $2\frac{1}{2}$ miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Discussion.—Another specimen in the collection, 109355, is a crushed valve having ornamentation similar to the above. The specimen was taken from the lower Athens formation from the prolific *Christiania* beds, $2\frac{1}{2}$ miles southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle, Tenn.

SPINILINGULA Cooper, new species

(Latin *spina*, a point)

Shells small to medium-sized, suboval in outline, biconvex, surface concentrically lamellose, lamellae broad with short prone spines on their anterior margin. Pedicle valve interior with deep pedicle groove bounded by two blisterlike, elongate plates forming long umbonal cavities. Plates marked by narrow grooves where they are attached to the side of the valve.

Brachial valve marked by a moderately long, undivided plate lying prone on the posterior surface, anteriorly emarginate. Brachial valve also marked by a faint median ridge, in adults extending from a point slightly posterior to the middle to the anterior margin.

Genotype.—*Spinilingula intralamellata* Cooper, new species.

Discussion.—This genus is characterized by an interior like that of *Lingulella* but with the exterior lamellose and spinose. It differs from other *Lingulellinae* in its exterior features.

SPINILINGULA INTRALAMELLATA Cooper, new species

Plate 2, A, figures 1-5; plate 11, J, figures 25-32

Shell small, longer than wide, suboval in outline, with the greatest shell width at about the middle. Apex acute forming an angle of about 70° . Lateral mar-

gins with nearly straight slopes from beak forming indistinct shoulder about one-third length of valves from beak; lateral margins rounded; anterior margin gently rounded; anterolateral extremities narrowly rounded. Surface marked by irregular concentric undulations that are crossed by irregular interrupted radial lines which terminate in short, prone spines. Shell lamellae broad and regularly spaced when seen on exfoliated specimens.

Pedicle valve very gently and evenly convex in lateral profile, broadly convex in anterior profile. Greatest convexity slightly posterior to the middle. Anterior slope gentle; lateral slopes short, moderately steep.

Brachial valve evenly and gently convex in lateral profile, flattened to gently convex in anterior profile. Umbonal region convex; anterior to umbo a broad, shallow sulcus extending to anterior margin. Outer slopes of folds bounding sulcus to lateral margins steep in posterior two-thirds but becoming gentle and obsolete toward the anterior.

Measurements in mm.—

| | Length | Width |
|---------------------------------------|--------|-------|
| Holotype (brachial valve) | 3.7 | 3.1 |
| Paratype (pedicle valve 116783) | 4.2 | 3.0 |

Types.—Holotype: 116784a; figured paratypes: 109281a-e, 116784b-h; unfigured paratypes: 116782a-i, 116783.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its ornamentation and small size. The exfoliated shell shows regular concentric lamellae, distant and evenly spaced, but well-preserved specimens show that the lamellae are covered by a surface layer marked by concentric undulations and irregular radial lines terminating in short spines. These features will serve to distinguish *S. intralamellata* from any known linguloid from rocks herein treated.

The appearance of radial ornamentation arises from the fact that the lamellae grow over the ends of the spines and therefore become wrinkled. This species is abundant at the Pratt Ferry locality but has not been seen elsewhere. It can be successfully etched from the limestone by acetic acid. Views of exfoliated shells as well as etched specimens have been included because of the frequent necessity of identifying specimens on fractured rock surfaces, which is the usual way fossils are encountered.

Subfamily ACANTHAMBONIINAE Cooper, new subfamily

Subcircular shells with interior apical structures of both like *Lingulella*. Exterior spiny.

ACANTHAMBONIA Cooper, new genus
(Greek *acanthos*, spine; *ambon*, umbo)

Shell minute, subcircular to suboval in outline; subequally biconvex; surface covered by minute, hairlike spines extending from the surface at a fairly high angle.

Pedicle valve with minute beak and broad apical angle; interior with narrow propareas marked by concentric lines and appearing as narrow folds on the posterior margin. Muscle marks so lightly impressed as to make it impossible to determine the individual muscles. Pedicle groove poorly defined.

Brachial valve generally somewhat deeper than the pedicle valve and usually marked medially by a shallow sulcus. Umbo swollen; interior with somewhat thickened margin, incurved and with a posteriorly directed wave at the beak which forms a notch. Muscle scars not deeply enough impressed to distinguish.

Genotype.—*Acanthambonia minutissima* Cooper, new species.

Discussion.—This genus is suggestive of *Leptobolus* but differs in the nature of the posterior margins of both valves and the ornamentation. The spiny exterior of *Acanthambonia* is a means of ready distinction between the two genera. The apical structures of both valves are suggestive of *Lingulella*, but the exterior is quite different. The genus is assigned to the Lingulellidae because the apical structures are suggestive of that family. The general habit of *Acanthambonia* is so different from that of the other Lingulellidae that the new subfamily is erected for it.

ACANTHAMBONIA MINUTISSIMA Cooper, new species

Plate 18, D, figures 23-27

Shell minute, biconvex, the brachial valve having a slightly greater convexity than the pedicle valve; beaks inconspicuous; outline nearly circular; surface, including posterior margin, marked by fine hairlike spines, and faint concentric lines of growth.

Pedicle valve moderately convex and with the greatest convexity located in the posterior third; anterior slope gently convex and moderately steep. Anterior profile fairly evenly and broadly convex; beak small, protruding slightly posterior to the posterior margin; umbo and median region inflated.

Brachial valve fairly strongly convex with the greatest convexity in the posterior third; anterior slope moderately long and gently convex, moderately steep; anterior profile swollen in the middle and with short and steep lateral slopes. Median sulcus shallow, originating just anterior to the umbo and widening to the front margin where it occupies about one-third the width.

Measurements in mm.—

| | Length | Width |
|---|--------|-------|
| Holotype (pedicle valve) | 1.4 | 1.3 |
| Paratype (brachial valve 116795a) | 1.6 | 1.4 |

Types.—Holotype: 116795b; figured paratypes: 116795a,c.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile south-east of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species differs from *A. virginensis* Cooper, new species, which occurs at about the same level in Virginia, by its small size and more scattered spines.

ACANTHAMBONIA VIRGINIENSIS Cooper, new species

Plate 9, A, figures 1-6

Shell small, nearly circular in outline and with a small beak; surface marked by crowded hairlike spines. Pedicle valve moderately convex in lateral profile but with the greatest convexity located in the posterior third which is somewhat swollen. Anterior slope long and gently convex. Umbonal region faintly carinate. Anterior profile moderately convex, swollen in the middle with moderately steep lateral slopes. Greatest width at the middle.

Brachial valve moderately convex in lateral profile but with the greatest depth at the middle; median region swollen; lateral and anterior slopes fairly steep.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (brachial valve) | 2.1 | 2.1 | ? |
| Paratype (pedicle valve 116797a) | 2.7 | 3.5 | 0.6 |

Types.—Holotype: 116797e; figured paratypes: 116797a-d; unfigured paratypes: 116797f-h.

Horizon and locality.—Botetourt formation in Virginia: Field on the south side of the road 0.2 mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Discussion.—This species was recovered in debris from the etching of limestone blocks by hydrochloric acid. The species is suggestive of *A. minutissima*, but it is a much larger shell with more numerous spines. The surface of *A. virginensis* is densely crowded with minute, delicate, and long spines. Furthermore, the pedicle interior has more strongly developed propareas.

Subfamily GLOSSELLINAE Cooper, new subfamily

Elongate and narrowly oval oboloids with pedicle groove; brachial valve without concave apical plate, posterior margin more or less thickened.

Genus LEPTOBOLUS Hall, 1871

Plate 12, A, figures 1-4; plate 12, B, figures 5, 6

Shells small, oval in outline with subequally convex valves. Brachial valve generally more convex and rounder in outline than the pedicle valve. Beak of pedicle valve pointed. Surface of both valves ornamented by fine concentric lines and, in one species, fine radial lines. Pedicle interior characterized by a pedicle groove with narrow propareas on each side. Low median ridge anterior to pedicle groove extending nearly to the middle where it forks narrowly, each prong of the fork extending to about the middle of the valve and forming a shallow V-shaped chamber.

Brachial valve characterized by a complete posterior margin with small callosity at the apex. Interior surface marked by 1 or 3 low ridges. Median ridge the longer and extending nearly to the front margin where it is minutely forked. Lateral ridges shorter than the median ridge and not present in all species, diverging toward the anterolateral margin.

Discussion.—The genus *Leptobolus* has been widely identified, but no unequivocal species of the genus has been found in the rocks treated in this monograph. A small brachiopod having the exterior form of *Leptobolus* occurs in the Liberty Hall facies of Virginia, but it fails to show the characteristic septa in either valve. The best-preserved and unquestionable members of the genus occur in Trenton-Cincinnatian rocks, but Reudemann described an unusually large species, *L. walcotti*, from the Normanskill shale. According to his illustrations the brachial valve has a median septum. This, then, would probably be the oldest member of the genus unless this part of the Normanskill should prove to be of the same age as Trenton sedimentation.

Elliptoglossa has been confused with *Leptobolus*, but even casual examination of the interiors should obviate confusion. Actually the exterior form and ornamentation of the two genera are quite different, but examination of the interior details will settle the generic identity. *Elliptoglossa* is one of the peculiar brachiopods not provided with a pedicle groove, and no species has yet been found that has septa like those of *Leptobolus*.

LEPTOBOLUS WALCOTTI Ruedemann

Leptobolus walcotti RUEDEMANN, New York State Mus. Bull. 42, p. 569, pl. 1, figs. 6-12, 1901.

Horizon and locality.—Normanskill shale in New York: At Kenwood and Glenmont near Albany; Mount Merino near Hudson.

LEPTOBOLUS ? sp. 1

Plate 12, C, figures 7, 8

Shells minute, oval in outline with the greatest width anterior to the middle. Pedicle valve nearly flat to very gently convex in lateral profile, gently convex in anterior profile. Brachial valve unevenly convex with the greatest convexity in the umbonal region. Anterior profile moderately convex. Umbonal and median regions swollen; anterior and lateral slopes gentle. Surface of both valves marked by distant growth lamellae and fine concentric lines. Details of the interior obscure.

Figured specimens.—109344a,b.

Horizon and locality.—Edinburg formation (Liberty Hall facies) in Virginia: Middle River north-northeast of Staunton, Staunton (15') Quadrangle.

LEPTOBOLUS ? sp. 2

Two specimens from the upper 40 feet of the Edinburg limestone in the section $\frac{1}{2}$ mile west of Strasburg are larger than the above, and the exterior is ornamented by distinct and numerous radial wrinkles as well as fine concentric lines. No details of the interior can be distinguished.

Described specimens.—109343a,b.

Genus **PSEUDOLINGULA** Mickwitz, 1909**PSEUDOLINGULA AQUILINA** Sinclair

Pseudolingula aquilina SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 60, pl. 1, fig. 12, 1945.

Type.—Holotype: G.S.C. 1160.

Horizon and locality.—Age uncertain; "either pre-Lowville Black River or Chazy"; in green siliceous limestone 25 feet from the base of the Ordovician section at a cliff halfway between Malbai and Cap à l'Aigle, Murray Bay, Quebec, Canada.

PSEUDOLINGULA ? EVA (Billings)

Lingula eva BILLINGS, Canadian Nat. Geol., vol. 6, p. 150, 1861.—BILLINGS in Logan, Geol. Canada, p. 141, fig. 73, 1863.

Pseudolingula ? eva (Billings) SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 60, pl. 1, figs. 16, 17, 1945.

Lingulasma eva (Billings) WILSON, Geol. Surv. Canada, Bull. 8, p. 21, pl. 1, figs. 21-23, 1946.

Types.—Lectotype: (G. W. Sinclair, 1945) G.S.C. 1160a; paratype: G.S.C. 1160b.

Horizon and locality.—Black River ? formation, Murray Bay, Quebec, Canada.

Discussion.—This species was recently discussed by Sinclair and Wilson. These authors assign it to different genera. Wilson's remarks do not indicate that the ornamentation of the holotype is like that of *Lingulasma*. No mention is made of the beaded exterior so characteristic of that genus and the figures of the type show only strong concentric undulations. A third specimen (G.S.C. 6325), assigned by Miss Wilson to this series, is by its ornamentation definitely an example of *Lingulasma*. It is doubtful, however, that it belongs to the species to which it is assigned.

PSEUDOLINGULA ? IMPERFECTA Cooper, new species

Plate 5, D, figures 9-11; plate 6, E, figures 18-22

Shell large for an Ordovician member of the genus, thin in substance, usually light lustrous bluish gray to horn brown in color. Strongly and subequally biconvex in anterior and lateral profiles, subelliptical to oval in outline. Posterolateral margins widely divergent, nearly straight, forming somewhat narrow shoulders where joining the lateral margins. Lateral margins very gently convex, subparallel, abruptly joining the somewhat strongly convex anterior margin. Surface marked by broad concentric undulations on the median portion of both valves but narrowly convex and closely crowded on the lateral slopes. Ornamentation on lateral slopes often gently wavy and some of the lines discontinuous and irregular in direction.

Pedicle valve with imperfect beak in all specimens examined. Brachial valve with thickened and inflected posterior margin; beak protruding beyond the posterior margin.

Measurements in mm.—Holotype, length 22.8+, width 19.6, thickness 8.2.

Types.—Holotype: 109303b; figured paratypes: 109303d, 116762a,b; unfigured paratypes: 109303a,c, 116762c.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—No perfect specimens of this species are known although many collections were taken from Rock Crossing, where it is frequent but not common. The two brachial beaks preserved are rather imperfect but indicate a thickened inner band. The species is not like any other *Pseudolingula* herein described.

PSEUDOLINGULA ? LUTTRELLENSIS Cooper, new species

Plate 1, D, figures 6-12

Shell substance thin, shell large but compressed; subpentagonal in outline. Width equal to about three-fourths the length. Apical angle of the pedicle valve 104° . Posterolateral margins straight; posterolateral extremity somewhat narrowly rounded; lateral margins very gently curved; anterolateral extremities narrowly rounded and the anterior margin gently convex. Greatest width slightly anterior to the middle. Surface marked by fine, wavy concentric lines, stronger on the flanks than on the central portion, where they are very fine.

Pedicle valve very gently convex in both profiles, shallow. Anterior third broadly sulcate; posterior two-thirds of valve slightly swollen and forming the deepest part.

Brachial valve more convex than the pedicle one and with the median portion of the posterior two-thirds swollen gently and moderately convex. The lateral slopes to the margins are short and fairly steep but the posterior slope, occupying the anterior third is long and gentle. Posterior margin narrowly rounded. Beak low, protruding slightly posterior to the posterior margin.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Paratype (pedicle valve 109286a) | 20.5 | 15.2 | ? |
| “ (brachial valve 109286c) | 19.3 | 15.0 | 1 ? |

Types.—Holotype: 109286b; figured paratypes: 109286a,c.

Horizon and locality.—Moccasin formation in Tennessee: Near Luttrell, Luttrell (T.V.A. 155-NW) Quadrangle.

Discussion.—The outline and compressed form of this species suggest affinity with *Lingulella brainerdi* and *P. ? eva*. It differs from the former in having a more beautiful and complex concentric ornamentation, a more obtusely angular beak, and less abruptly rounded anterolateral extremities. *Pseudolingula ? eva* has similar proportions to *P. ? luttrellensis* but is somewhat more acuminate apically and more broadly rounded anteriorly.

PSEUDOLINGULA PYXIDATA Sinclair

Pseudolingula pyxidata SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 59, pl. 1, fig. 10, 1945.

Type.—Holotype: Private collection G. W. Sinclair.

Horizon and locality.—Black River?, Rivière Sault à la Puce, Montmorency County, Quebec.

PSEUDOLINGULA ? SCULPTATA Cooper, new species

Plate 3, B, figures 2-5

Description based on a brachial valve which is moderately large, subovate in outline and with alternate broad bands of gray and pale brown. Apical angle about 80° ; posterolateral margins forming an indistinct shoulder with lateral margins which are gently rounded. Anterolateral extremities narrowly rounded; anterior margin gently rounded. Slightly convex in lateral and anterior profiles. Surface marked by fine concentric undulations of growth crowded and wavy on the flanks; on the body of the valve numerous radial striae break up the concentric lines into fine elevated scallops.

Measurements in mm.—Holotype, length 19+, width 12.5.

Type.—Holotype: 45065.

Horizon and locality.—Camp Nelson formation in Kentucky: Opposite the railroad station at High Bridge, Harrodsburg (30') Quadrangle.

Discussion.—This species suggests *P. ? luttrellensis* in its size and form but differs therefrom in the nature of the ornamentation. The latter species does not have the numerous fine radial striae interrupting the concentric marks.

PSEUDOLINGULA sp. 1

Shell large, subrectangular in outline with nearly straight and parallel sides. Beaks missing; surface distinctly marked. Posterolateral areas with strong concentric undulations which broaden anteriorly to disappear in the anterior half which is nearly smooth. Fine undulations appear between the stronger ones in the posterolateral area. Interior of one valve with a strongly developed callosity.

Described specimen.—116773.

Horizon and locality.—Shippensburg formation (Pinesburg member-*Nidulites* zone) in Maryland: On U. S. Highway 40 on the west side of Conococheague Creek at Wilson, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—The specimen is recorded here in the hope that others will look for better material. Its ornamentation and the muscle callosity suggest a new form.

Genus **ECTENOGLOSSA** Sinclair, 1945

ECTENOGLOSSA ? LYELLI (Billings)

Plate 3, C, figures 6, 7

Lingula lyelli BILLINGS, Canadian Nat. Geol., vol. 4, p. 348, figs. 1a-1d; p. 431, 1859.—BILLINGS in Logan, Geology of Canada, p. 124, fig. 49, 1863.

Lingula lyelli Billings, RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 218, pl. 33, fig. 5, (fig. 6, doubtful), 1911.

Lingula lyelli Billings, SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 67, 1945.

Types.—*Lectotype* (G. W. Sinclair, 1945): G.S.C. 1027C; *paratype*: G.S.C. 1027.

Horizon and locality.—Aylmer formation (Rockcliffe member), Allumette Island, Ottawa River, Pontiac County, Ontario, Canada.

ECTENOGLOSSA NYMPHA (Billings)

Lingula nympha BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 214, fig. 198, 1865.—AMI, Ottawa Nat., vol. 8, p. 85, 1894.

Ectenoglossa nympha (Billings) SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 64, pl. 2, figs. 3-6, 1945.

Types.—*Lectotype* (Sinclair, 1945): G.S.C. 553; *paratype*: G.S.C. 553.

Horizon and locality.—Table Head series, Table Head, Newfoundland.

ECTENOGLOSSA NYMPHOIDEA Cooper, new species

Plate 2, E, figures 12-20; plate 6, B, figure 6

Lingula nympha RAYMOND (not Billings), Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 293, pl. 1, fig. 1, 1928.

Shell large for the genus, length equal to about twice the width. Lateral margins gently curved; the greatest width located at about the middle. Anterior margin narrowly rounded. Beak angle about 80°. Surface where preserved marked by concentric lines.

Valves subequal in depth, moderately convex in profile with the greatest convexity and depth located in the posterior third. Anterior profiles moderately convex but with the top of the curve flattened. Anterior two-thirds flattened and with long gentle slopes to the front margin. Lateral slopes steep in the posterior third but becoming more gentle anteriorly.

Interior details difficult to determine but pedicle valve thickened slightly anterior to the middle and in a path extending anteriorly along the median portion of the valve by the growth track of the large anterior muscles. Median ridge present in the brachial valve.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (pedicle valve) | 51.3 | 26.7 | 3.0 |
| Paratype (brachial valve 71822a) | 52.1 | 25.3 | 4.5 |
| " (" " 109289) | 36.1 | 19.2 | 2.0 ? |

Types.—Holotype: 109292d; figured paratypes: 71822a, 109289, 109292e, 109297a,b; unfigured paratypes: 71822b, 109292a-c,f; figured specimens: 109293, 116778a.

Horizon and locality.—Whitesburg formation in Tennessee: On Bulls Gap (T.V.A. 171-SE) Quadrangle, under the Southern RR. bridge about 1,000 feet east of the station at Bulls Gap; road cut $\frac{3}{4}$ mile southeast of Whitehorn; rail-

road cut at Summit Hill School 1 mile southwest of Otes; $1\frac{1}{2}$ miles northeast of Bulls Gap; $1\frac{1}{2}$ miles west of Bulls Gap. Edinburg formation (Liberty Hall facies) in Virginia: 300 feet west of Route 3, $\frac{3}{4}$ mile northeast of Nineveh, Winchester (15') Quadrangle; opposite the bridge at Riverton; near Front Royal, Front Royal (15') Quadrangle.

Chatham Hill formation in Virginia: John Grayson Farm, 4 miles southwest of Bland, Bland County.

Paperville formation in Virginia: $\frac{1}{2}$ mile northwest of Hollins School, Roanoke (15') Quadrangle.

Discussion.—This is one of the largest known species of linguloid, and the recorded dimensions given above are not those of the largest specimens, but of the most perfect ones. An imperfect individual from the Athens shale of Whitehorn, Tenn., measures 69 mm. in length, but portions of the anterior and posterior are missing, which would probably place the actual length in the neighborhood of 75 mm., or 3 inches. The width of the specimen is 29 mm.

This species is most like *E. nympa* Billings from the Table Head formation of Newfoundland but differs in being proportionally narrower and with less deep valves. Billings' species is 3 times as long as wide, and its sides are more parallel than those of *E. nymphoidea*.

ECTENOGLOSSA ? RUBRA Cooper, new species

Plate 8, J, figures 21-26

Shell large, somewhat quadrate in outline. Lateral margins nearly parallel; anterolateral extremities narrowly rounded, anterior margin gently curved; apex obtusely angular. Surface marked by scattered concentric undulations and very fine, concentric, closely crowded, wavy lines particularly on the median region.

Pedicel valve with greatest depth slightly posterior to the middle; anterior and posterior slopes gentle; anterior profile broadly convex, flattened in the median area and with short moderately steep lateral slopes. Brachial valve somewhat deeper than the pedicel valve but with similar profiles.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 36.2 | 20.2 | 5.0 ? |
| Paratype (116777b) | 21.2+ | 16.8 | 9.2 |

Types.—Holotype: 116777a; figured paratype: 116777b; unfigured paratypes: 116777c,d.

Horizon and locality.—Base of the Bays formation in Tennessee: $1\frac{1}{2}$ miles south-southeast of Houk, Loudon (30') Quadrangle= 0.15 mile northeast of Fourmile Church, Tallassee (T.V.A. 139-SE) Quadrangle.

Discussion.—This species is interesting because it occurs in red beds. It is characterized by its deep and elongate valve. It is somewhat like *E. nymphoidea* but is not so large and is differently ornamented. The finely crinkled lines are quite distinctive.

ECTENOGLOSSA ? SCULPTA Cooper, new species

Plate 4, C, figures 9-13

Shell fairly large, light bluish gray in color on the outer surface but with inner layers grayish brown; outline longitudinally and narrowly elliptical; sides subparallel, gently convex; widest at about the middle; anterior narrowly rounded; posterior bluntly pointed but apical angle unknown; surface marked by closely crowded, elevated concentric lines and ridges, most prominent on the lateral slopes; concentric ornamentation crossed by fine radial striae which are most prominent in the median region.

Pedicle valve slightly deeper than the brachial one; greatest depth at about the middle with long, gentle anterior and posterior slopes; anterior profile fairly strongly convex with moderately steep lateral slopes. Brachial valve with narrowly rounded posterior margin; lateral profile flattened in the median half and with the anterior and posterior quarters sloping to the extremities. Anterior profile slightly less convex than that of the pedicle valve.

Measurements in mm.—Holotype, length 25.7, width 14.9, thickness 7.7.

Types.—Holotype: 109302b; figured paratype: 109302a; unfigured paratype: 109302c.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectia gouldi* zone) in Carter County, Okla.: Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills; on a branch of Hickory Creek in NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., Crier Hills.

Discussion.—This species is doubtfully referred to the genus *Ectenoglossa* because of its long and slender form, but the "teeth" referred to by Sinclair, author of the genus, were not seen. The species is further distinguished by the radial elements on an otherwise *Lingula*-like ornament. It differs from *E. nymphoidea* by its more slender dimensions and details of the ornamentation.

ECTENOGLOSSA sp. 1

Plate 8, B, figures 4, 5

Shell thin, large for the genus, oval in outline, width about two-thirds the length; posterior margin somewhat narrowly rounded; sides gently curved; anterior margin slightly more broadly rounded than the posterior margin. Greatest width at the middle. Surface marked by fine concentric lines and broad concentric undulations.

Measurements in mm.—

| | Length | Width |
|---------------|--------|-------|
| 116776b | 25.0+ | 16.7 |
| 116776a | 23.1 | 14.8 |

Figured specimens.—116776a,b.

Horizon and locality.—Upper Table Head series, Port-au-Port, Newfoundland.

Discussion.—The two specimens (probably pedicle valves) in the collection

suggest relationship to *E. nympa* and *E. nymphoidea*, but they represent a smaller shell than either of the two mentioned. Possibly the present specimens represent young of the former, but this cannot be established in their partially crushed state.

Genus **PALAEOGLOSSA** Cockerell, 1911

PALAEOGLOSSA ? BELLI (Billings)

Plate 7, F, figures 25-29

Lingula belli BILLINGS, Canadian Nat. Geol. vol. 4, p. 431, figs. 7, 8, 1859; Geol. Surv. Canada, 15th Rep. Progress, p. 124, figs. 47a, b, 1863.

Obolus belli (Billings) WALCOTT, U. S. Geol. Surv. Mon. 51, pt. 1, p. 386, pt. 2, pl. 38, figs. 3a, b, 1912.

Specimens referred to this species by Raymond are not here included in the synonymy because the specimens are too badly damaged and are much smaller in size. It is not now possible to place them properly; better material will be needed for certain identification.

Types.—Lectotype (Walcott, 1912, pt. 2, p. 130): G.S.C. 1026b; paratype: G.S.C. 1026c; figured specimens: U.S.N.M. 109231a,b; Carnegie Mus. 5431.

Horizon and locality.—St. Martin formation, Island of Montreal, Quebec; base of Chazy group, Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle, N. Y.

PALAEOGLOSSA MYSTICENSIS Cooper, new species

Plate 9, G, figures 17-19

Shell of about medium size for the genus, light gray in color, length approximately $1\frac{1}{2}$ times the width. Beak narrow; sides gently rounded and diverging to the anterior margin which is narrowly rounded. Greatest width at a point a short distance anterior to the middle. Lateral profile slightly convex; anterior profile broadly convex but with moderately steep and short lateral slopes. Interior with long median ridge extending for about half the valve length.

Measurements in mm.—Holotype (estimated), length 11.5, width 7.6.

Types.—Holotype: 66285a; figured paratypes: 66285b,c; unfigured paratypes: 66285d-f.

Horizon and locality.—Mystic conglomerate in Quebec: Range 6, Lot 20, near Mystic, Stanbridge Township.

Discussion.—This species is characterized by the long median septum in the brachial valve, which is the only valve available for study. It differs from *P. attenuata*, type of the genus, in its more slender form.

PALAEOGLOSSA ? PULICIS (Sinclair)

Lingula ? pulicis SINCLAIR, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 68, pl. 2, figs. 7-9, 1945.

Types.—Holotype and paratypes in private collection G. W. Sinclair.

Horizon and locality.—Black River?, Rivière Sault à la Puce, Montmorency County, Quebec.

PALAEOGLOSSA sp. 1

Plate 10, C, figures 14-17

This is a large form, nearly twice as long as wide, with gently rounded sides and broadly rounded anterior margin. Valves subequally convex. Pedicle valve with apical angle of 95° . Brachial valve with broadly rounded posterior. Brachial valve with long median ridge.

Measurements in mm.—116775, length 19.5, width 11.5, thickness 4.2.

Figured specimen.—116775.

Horizon and locality.—Edinburg formation (*Cyrtototella* zone) in Virginia: 100 yards west of U. S. Highway 11, 1 mile northeast of Strasburg, Strasburg (15') Quadrangle.

PLECTOGLOSSA Cooper, new genus(Greek *plektos*, fold; *glossa*, tongue)

Oval in outline and lenticular in profile; brachial valve slightly deeper than the pedicle valve. Pedicle beak acute. Surface marked by regular, elevated concentric lines.

Pedicle beak with a depressed pedicle plate marked medially by a low fold. Posterior margin of brachial valve thickened as in *Pachyglossa*.

Genotype.—*Plectoglossa oklahomensis* Cooper, new species.

Discussion.—This genus is characterized by its oval outline and compressed lenticular profile with regular, elevated concentric ridges. The interior of the posterior margin of the brachial valve is like that of *Pachyglossa*, but the apical features of the pedicle valve are unlike any other linguloid described herein in having a concave apical plate marked medially by a low fold. The exterior form and ornamentation of this genus suggest *Trigonoglossa*, but that genus differs in having a more triangular outline, more compressed valves, and a different type of pedicle plate. In *Trigonoglossa* this plate is deeply concave and lies close to the floor of the valve. Furthermore, the sides are not marked by a ridge and are much more narrowly folded.

PLECTOGLOSSA OKLAHOMENSIS Cooper, new species

Plate 6, C, figures 7-15

Shell small, grayish blue to black in color, oval in outline. Posterolateral margins straight, forming indistinct shoulders where they join the lateral margins at about one-third the length from the beak. Greatest width at about the middle. Lateral margins gently rounded; anterior margin strongly rounded. Surface marked by distant, fairly evenly spaced raised concentric lines between which occur irregular fine concentric lines. Young portions of valves at umbones dark and smooth, marked only by fine concentric lines.

Pedicle valve with narrow beak; lateral profile moderately convex with the greatest convexity near the middle; anterior slope long and gentle; anterior profile fairly strongly convex and somewhat swollen medianly; lateral slopes

flat and moderately steep. Pedicle groove wide but marked medianly by a low longitudinal swelling.

Brachial valve with beak protruding slightly posterior to the posterior margin; deeper than the pedicle valve with a moderately convex lateral profile; anterior profile broadly convex with moderately steep slopes; anterior slope long and gentle.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------|--------|-------|-----------|
| Paratype (109294) | 11.2 | 7.6 | 1.8 |
| " (116763) | 10.3+ | 7.7 | 3.0 |
| " (116764) | 10.8 | 7.3 | ? |

Types.—Holotype: 116765; figured paratypes: 109294, 116763, 116764.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectia gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek about center of sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County; and on Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—In ornamentation this species suggests *Lingulella virginiensis*, but it differs in its more broadly oval form and greater size.

It is also suggestive of *P. sp. 1* from Benbolt formation which has distant elevated, concentric lines. The Benbolt species seems to have been a much larger shell and with more distantly spaced concentric lines.

PLECTOGLOSSA sp. 1

Plate 8, I, figures 19, 20

This is a fragmentary specimen with imperfect beaks and with the anterior third missing. The ornamentation, however, is very distinctive. The valves are of subequal depth but with the brachial valve slightly the deeper. The umbonal and median regions of this valve are somewhat swollen and have steeper lateral slopes than those of the pedicle valve. The ornamentation consists of strong, elevated concentric lines, crowded in the posterolateral areas but swinging apart and subequally spaced on the median areas.

Figured specimen.—116774.

Horizon and locality.—Benbolt formation in Virginia: 0.2 mile south of the middle fork of Moccasin Creek, 1 $\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

PACHYGLOSSA Cooper, new genus

(Greek *pachys*, thick; *glossa*, tongue)

Elongate elliptical in outline, strongly biconvex but the brachial valve generally having the greater convexity. Shell usually thick. Surface marked only by growth lines and concentric wrinkles.

Interior of pedicle valve with posterior structure like that of *Lingulella* with a deep pedicle groove margined by concentrically marked thickenings. Posterior margin of brachial valve slightly thickened and without a posterior plate.

Genotype.—*Pachyglossa dorsiconvexa* Cooper, new species.

Discussion.—This genus is suggestive of *Lingulella* but differs in profile and in the character of the posterior margin of the brachial valve. *Pachyglossa* is usually strongly biconvex whereas *Lingulella* is generally flatly biconvex. The interiors of the pedicle valves of both genera are similar but the posterior margins of the brachial valves are different. In *Lingulella* the posterior of the brachial valve is occupied by a concentrically marked concave plate. In *Pachyglossa*, on the other hand, the posterior margin is unmodified and there is no concave plate. The margin may be more or less thickened, but that is the only modification detected. Other species assigned to this genus are *P. biconvexa* of the Bromide of Oklahoma and *P. pachydermata* from the Effna formation of Virginia.

PACHYGLOSSA BICONVEXA Cooper, new species

Plate 7, A, figures 1-12

Shell of about medium size for the genus, strongly biconvex in lateral profile, elongate-oval in outline with the shell substance thick. Lateral margins broadly curved with the greatest width slightly anterior to the middle. Anterior margin somewhat narrowly rounded. Beak angle about 100° . Surface marked by fine and strong concentric growth undulations.

Pedicle valve having the lateral profile unevenly convex with maximum convexity slightly posterior to the middle; anterior profile somewhat narrowly rounded, the elevation equal in height to about one-quarter the width. Beak not conspicuous but meeting the margin. Umbonal region slightly swollen, the swelling continuing to a point slightly anterior to the middle. Posterolateral slopes steep but anterior slope long and only moderately steep.

Brachial valve having profiles similar to those of the pedicle valve but more convex. Posterior margin broadly rounded and only slightly narrower than the anterior margin. Umbonal region narrowly convex and the median portion of the valve conspicuously swollen and with slopes similar to those of the pedicle valve.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Paratype (pedicle valve 109269a) | 11.2 | 11.8 | 2.8 |
| " (brachial valve 109269b) | 13.7 | 10.6 | 2.9 |
| " (" " 109271m) | 15.9 | 11.4 | 2.8 ? |

Types.—Holotype: 109271g; figured paratypes: 109269a, 109271f,j,m; unfigured paratypes: 109269b, 109271a-e,h,i,k,l.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: At Rock Crossing over Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County; on a branch of Hickory Creek in NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., Criner Hills west of Overbrook, Criner Hills, Carter County.

Discussion.—This species is characterized by the nearly equal and strong convexity of both valves in the median region. In this respect it differs from *P. ?*

elderi which it somewhat resembles. The shell of *P. biconvexa* is unusually thick and shows some marks of the internal structure. Unfortunately the specimens which showed these marks were prepared by burning the shell in a blast lamp and then flaking off with a needle. The details obtained are not sufficiently clear to make an adequate description of the interior.

PACHYGLOSSA DORSICONVEXA Cooper, new species

Plate 11, F, figure 11; plate 28, C, figures 7, 8

Shell small, brown to blue-gray in color, elliptical in outline with the length slightly greater than the width; greatest width at the middle. Pedicle valve with the posterolateral margins nearly straight and forming an apical angle of about 80° ; sides gently rounded; anterior margin narrowly rounded; pedicle valve with lateral profile gently convex and with the greatest convexity at about the middle; anterior and posterior slopes gentle; anterior profile moderately convex. Pedicle interior with deep pedicle groove between lateral folds.

Brachial valve with subequally rounded extremities and gently rounded sides; lateral profile strongly convex; greatest depth about one-third the length from the beak; anterior slope long and gentle; anterior profile somewhat narrowly rounded and with steep lateral slopes. Beak marginal. Surface of both valves marked by irregular, strong concentric undulations.

Brachial interior with thickened posterior margin which is not inflected. Muscle pattern not clear.

Measurements in mm.—Holotype, length 7.2, width 5.0, thickness 1.8?

Types.—Holotype: 116758a; figured paratype: 117976; unfigured paratypes: 116758b-g, 117976a-f.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species in its strongly convex and elliptical brachial valve strongly suggests a small *P. biconvexa* from the Bromide of Oklahoma. The colors are also similar. Nevertheless, the species are different. The Oklahoma one is much larger, and the brachial valve is proportionally less convex.

PACHYGLOSSA ? ELDERI (Whitfield)

Plate 5, E, figures 12-14

Lingula elderi WHITFIELD, Amer. Journ. Sci., ser. 3, vol. 19, p. 472, figs. 1, 2, 1880. For further synonymy see Bassler, U. S. Nat. Mus. Bull. 92, p. 728, 1915.

Figured specimens.—24734a, 45015a.

Horizon and locality.—Platteville limestone (McGregor) and Decorah (Spechts Ferry) formation, Minnesota and Wisconsin.

PACHYGLOSSA PACHYDERMATA Cooper, new species

Plate 5, F, figures 15-18; plate 6, A, figures 1-5; plate 27, C, figure 8

Shell of medium to large size, dark brown to black in color, generally thick; longer than wide with the length about $1\frac{1}{2}$ times the width; valves unequally bi-

convex, the brachial valve having the greater convexity. Lateral margins broadly rounded; posterior margin bluntly pointed, forming an angle of about 80° . Surface marked by strong concentric undulations.

Pedicle valve unevenly convex in lateral profile with the greatest convexity located about a third the length anterior to the beak. Anterior profile fairly strongly convex with flat and moderately steep lateral slopes. Anterior slope long and gentle. Umbonal region swollen. Pedicle valve with broad, shallow pedicle groove; brachial valve with evidence of a long, low median ridge.

Brachial valve deeper than the pedicle one and with the greatest convexity just posterior to the middle; anterior profile strongly convex with steep lateral slopes. Anterior slope moderately steep. Outline broadly elliptical with anterior and posterior margins subequally rounded.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------|--------|-------|-----------|
| Holotype | 26.0+ | 16.4 | 7.3+ |
| Paratype (109337) | 19.3 | 15.5 | 3.0 |

Types.—Holotype: 116767; figured paratypes: 109337, 116766, 116768.

Horizon and locality.—Botetourt formation in Virginia: At the junction of Virginia Highways 311 and 114, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle; Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Chatham Hill formation in Virginia: At Grayson Farm, 4 miles southwest of Bland, Bland County.

Benbolt formation in Virginia: At the Tazewell County Farm, 1 mile east of Tazewell, Burkes Garden (15') Quadrangle.

Pratt Ferry limestone in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species can be readily recognized by its large size and generally thick shell. It is suggestive of *P. biconvexa* but is much larger, differently colored, and thicker shelled. Specimens referred to this species from Pratt Ferry, Porterfield Quarry, and the Benbolt at the Tazewell County Farm seem to be younger specimens with thinner shells. Possibly the thinner shell in the latter instances constitutes an environmental difference.

GLYPTOGLOSSA Cooper, new genus

(Greek *glyptos*, engraved; *glossa*, tongue)

Elongate oval linguloids with moderately convex valves ornamented by concentric lamellae scalloped along their margins. Brachial interior with median septum reaching to about the valve middle.

Genotype.—*Glyptoglossa cavellosa* Cooper, new species.

Discussion.—Little is known of the interior of this genus except that the brachial valve is provided with a median septum. The generic separation is made on the basis of the unusual ornamentation.

In the Girvan fauna of Scotland *Lingulasma* ? *ardmillanense* Reed has the

same type of ornamentation and is thus assigned to *Glyptoglossa*. It also has a median septum in the brachial valve. This species does not show the usual plate-forms so characteristic of *Lingulasma*.

GLYPTOGLOSSA CAVELLOSA Cooper, new species

Plate 3, E, figures 13-20

Shell elongate-oval, length about twice the width. Sides gently rounded; anterior margin narrowly rounded, posterior bluntly pointed. Surface marked by crowded concentric undulations on the sides, but where these swing over the body of the shell they are scalloped. The overlapping of the scalloped lamellae creates a pock-marked appearance on the outer surface.

Lateral profile moderately convex with the maximum convexity in the median region. Anterior profiles broadly convex. Anterior third of both valves somewhat flattened.

Measurements in mm.—Holotype (minus beaks), length 19.0+, width 10.2, thickness 4.0+.

Types.—Holotype: 109273; figured paratypes: 109272a,d; unfigured paratypes: 109272b,c.

Horizon and locality.—Shippensburg formation (Pinesburg member-lower part *Echinosphaerites* zone) in Maryland: On U. S. Highway 40, at Wilson, on the west side of the bridge over Conococheague Creek, 7 miles west of Hagerstown; same formation (lower part *Nidulites* zone), same as preceding; Williamsport (15') Quadrangle. At the same horizon in the railroad cut 2 miles southwest of Marion, Chambersburg (15') Quadrangle.

Discussion.—This species is characterized by the peculiar scalloping of the lamellae on the body of the shell, an ornamentation unlike that of any other species herein described. Paratype 109272d, a partially exfoliated brachial valve, shows an impression of a median ridge and the folded collar.

GLYPTOGLOSSA sp. 1

Plate 13, B, figure 4

Two specimens are characterized by a peculiar ornamentation consisting of strong, concentric elevated lines with interspaces of about the same width as the lines. The elevated lines are crowded on the posterolateral slopes but are more distantly spaced on the median and posteromedian areas. The known specimens indicate a small linguloid having a length of about 11 mm. and a width of about 7 mm. The known valves are shallow, and the outline is the characteristic oval of many Ordovician linguloids.

Figured specimen.—116770.

Horizon and locality.—Effna formation in Virginia: McNutts Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Chatham Hill formation in Virginia: On the Grayson Farm, 4 miles southwest of Bland, Bland County.

GLOSSELLA Cooper, new genus(Greek *glossa*, tongue)

Shell fairly large, thin, longer than wide and with sides gently curved but sub-parallel; surface marked by concentric and radial rows of small pustules. In the posterior and median portion of the valves pustules densely crowded and matted to give a shagreen surface. At the anterior and on the lateral areas the pustules are arranged in more distant lines. Pedicle interior with narrow propareas between which is suspended a shallow concave plate. Muscle marks not clearly visible in material at hand. Brachial valve with concave propareas and an inflected margin at the beak which is formed by the posterolateral margin of the shell gradually turning through an angle of about 90° . Muscle scars not discernible in the material at hand.

Genotype.—*Glossella papillosa* Cooper, new species.

Discussion.—This genus is based on the linguloid form of the shell combined with its hinge-region structures and the peculiar ornamentation. The ornamentation is suggestive of *Lingulasma*, but the interior platforms are not present in *Glossella*. Furthermore, the ornamentation is not precisely like that of *Lingulasma*. The latter genus generally has more distant radial lines, and the pustules are often defined by gashes or pits.

GLOSSELLA LIUMBONA Cooper

Plate 4, A, figures 1-4; plate 9, I, figures 23-25; plate 13, E, figures 7-12

Shell fairly large, elongate, length about twice the width, narrowly elliptical in outline, with gently rounded lateral margins; posterior margin bluntly pointed; anterior margin narrowly rounded. Unequally biconvex in lateral profile, the pedicle valve having the lesser convexity; surface marked by concentric undulations which are crossed by radial and concentric rows of pustules. Umbonal region of both valves marked by concentric undulations only. Surface in postero-median portion of valve having a shagreen surface where ornamentation is very fine.

Pedicle valve gently convex in lateral profile, with the deepest part located near the middle; umbonal region smooth for about 1 mm. Brachial valve broadly convex in lateral profile, with the greatest convexity located at about the middle; anterior profile considerably more convex than that of the pedicle valve, swollen medianly and with fairly long and steep lateral slopes.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------|-------------|-------|-----------|
| Holotype | 20.9+ | 12.3 | 5.7 |
| Paratype (116786) | 11.2 actual | ? | ? |
| " (109285) | 9.5 | 4.6 | ? |
| " (116785b) | 16.3 | 10.1 | 3.4 |

Types.—Holotype: 116785a; figured paratypes: 109285, 116785b, 116786.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplecta gouldi* zone) in Oklahoma: Rock Crossing of Hickory Creek about center sec.

35, T. 5 S., R. 1 E., Criner Hills, Carter County; (Pooleville member-bed 5) Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is represented by four specimens. Two of the specimens are apparently young. The species is characterized by its nearly smooth umbo, the densely granulated median region and the more distant well-aligned pustules on the flanks and anterior. It differs from *G. papillosa* from the Pratt Ferry Formation in its much larger size, less tapering sides and proportions.

GLOSSELLA PAPILOSA Cooper, new species

Plate 5, G, figure 19; plate 9, J, figures 26, 27; plate 11, G, figures 12-14

Shell of about medium size for the genus, wider than long, the length about twice the width; beak pointed, forming an angle of about 70°. Anterior margin narrowly rounded; sides subparallel; surface marked by extremely fine pustules densely matted in the median region but forming closely spaced rows on the flanks and anterior region. Umbonal region marked by concentric undulations and growth lines only.

Pedicle valve gently convex in lateral profile and broadly convex in anterior profile. Brachial valve considerably deeper than the pedicle one; lateral profile gently convex but most convex in the umbonal region; anterior profile moderately convex with a well-rounded median region and moderately long, steep lateral slopes.

Measurements in mm.—Holotype, length 11.3, width 7.0.

Types—Holotype: 116787b; figured paratypes: 116787d,e, 123305; unfigured paratypes: 116787a,c.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This is a much smaller species than *G. liumbona* from the Pooleville member of the Bromide formation and is much more oval in outline.

GLOSSELLA sp. 1

Plate 3, A, figure 1

This is the impression of about the posterior half of a linguloid having a probable length of about 12 mm. and a width of 5 mm. The specimen is an impression of the exterior showing numerous wavy lines and a mat of fine pustules.

Figured specimen.—109319.

Horizon and locality.—Botetourt formation in Virginia: Junction Virginia Highways 114 and 311, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle.

Superfamily TRIMERELLACEA Schuchert, 1929

Family TRIMERELLIDAE Davidson and King, 1874

Large, thick calcareous brachiopods usually subcircular to broadly oval in outline and lenticular in profile; pedicle attachment area large, triangular and transversely striated. Muscle scars of both valves large, and often elevated on thickened or hollow platforms.

Genus **OBOLELLINA** Billings, 1871

Obolellina BILLINGS, Canadian Nat., n. ser., vol. 6, p. 221, 1871.

Broadly oval shells suggesting *Dinobolus* on the exterior but with moderately developed broad and low platform in the pedicle valve and scarcely any development of a platform in the brachial valve. In any case the platforms are low and consist of broad thickening only, without elevation and excavation.

OBOLELLINA CANADENSIS (Billings)

Plate 24, E, figure 24

Obolus canadensis BILLINGS, Canadian Nat. Geol., vol. 3, p. 441, figs. 20-23 (not fig. 19 = *O. magnifica*), 1848; Geol. Surv. Canada, Rep. Progress for 1857, p. 189, figs. 20-23 (not fig. 19), 1858; Geol. Canada, p. 142, fig. 75, 1863.

Obolellina canadensis (Billings), Canadian Nat. Geol., n. ser., vol. 6, p. 222, 1871; *ibid.*, p. 326, fig. 15, p. 329, fig. 6, 1872.

Dinobolus canadensis (Billings) DAVIDSON and KING, Quart. Journ. Geol. Soc. London, vol. 30, p. 162, pl. 19, fig. 7, 1874.—WILSON, Geol. Surv. Canada, Bull. 8, p. 16, pl. 1, fig. 24, 1946.

Types.—Holotype: G.S.C. 1150; paratype: G.S.C. 1150a.

Horizon and locality.—Leray-Rockland beds, Fourth Chute of the Bonnechère River, Renfrew County, Ontario, Canada.

OBOLELLINA DIXONENSIS Cooper, new species

Plate 22, K, figures 18-21

Exterior of shell not known; length of beak not known; shell evidently thin. Valves subequally convex. Impressions of the pedicle interior indicate a transversely oval outline; lateral margins narrowly rounded; anterior margin broadly rounded. Lateral and anterior profiles broadly convex and nearly equal; lateral slopes short and moderately steep; median region depressed convex in anterior profile.

Pedicle interior with a moderately thickened, nonexcavated, diamond-shaped muscle area; sides of muscle area narrowly angulated in the middle; anterior narrowly rounded. Individual scars not clear, but a depressed track extending from the apex to the anterior angle suggests the growth path of 2 unidentified muscles. Brachial muscle platform similar in outline to the pedicle one; individual muscle marks not identifiable. The holotype (71814a) measures 15.2 mm. long by 20.3 mm. wide, representing measurement of interior surface only.

Types.—Holotype: 71814a; figured paratype: 71814b; unfigured paratypes: 71814c-i.

Horizon and locality.—Platteville formation (just above sponge bed), Truman's Quarry, 2 miles northeast of Dixon, Ill.

Discussion.—This species is suggestive of *O. parva* (Whitfield) from the Prosser limestone of Minnesota and Wisconsin but differs in being a larger and more transverse shell and in lacking any trace of median septa anterior to the muscle platforms.

Although only internal impressions are available for study, the species is assigned to *Obolellina* because of the modest thickening and nonexcavated character of the muscle platforms. The species evidently is an early form of dinobolid in which the muscle platforms are in an incipient stage of development.

OBOLELLINA ERECTA (Wilson)

Dinobolus erectus WILSON, Geol. Surv. Canada, Bull. 8, p. 17, pl. 1, fig. 25, 1946.

Type.—Holotype: G.S.C. 6301.

Horizon and locality.—Leray-Rockland beds, Fourth Chute of the Bonnechère River, Renfrew County, Ontario, Canada.

OBOLELLINA MAGNIFICA (Billings)

Plate 13, A, figures 1-3; plate 24, F, figure 25

Obolus canadensis BILLINGS (part), Geol. Surv. Canada, Rep. Progress for 1857, p. 189, fig. 19 (not figs. 20-23), 1858; Canadian Nat. Geol., vol. 3, p. 441, fig. 19 (not figs. 20-23), 1858.

Obolellina magnificus (Billings), *ibid.*, n. ser., vol. 6, p. 329, fig. 7, 1872.

Dinobolus magnificus (Billings) DAVIDSON and KING, Quart. Journ. Geol. Soc. London, vol. 30, p. 164, pl. 19, fig. 8, 1874.—NICHOLSON, Paleont. Province Ontario, p. 17, fig. 6, 1875.—WILSON, Geol. Surv. Canada, Bull. 8, p. 17, pl. 1, figs. 26, 27, 1946.

Broadly oval in outline, beak somewhat pointed, forming an angle of about 110° ; prominence of beak emphasized by a slight depression in the posterolateral margins. Lateral and anterior margins strongly rounded and approximately a circle. Valves unequally biconvex, the brachial valve having the greater convexity. Surface marked by concentric lines of growth and strong growth varices.

Pedicle valve gently convex in lateral profile and with the greatest convexity in the posterior third; anterior two-thirds somewhat flattened. Anterior profile broadly convex with long and gentle lateral slopes.

Brachial valve moderately and evenly convex in lateral profile; greatest convexity at about the middle; anterior profile with broadly swollen median area and short, moderately steep lateral slopes. Beak small, set off by short slopes; beak protruding slightly posterior to the posterior margin.

Pedicle interior with broad and shallow pedicle groove; posterior thickened by a broad muscle callosity extending to about the middle of the valve; muscle marks not preserved in the specimens at hand.

Brachial interior with unthickened posterior margin; posterior region thickened to form a muscle platform, perforated by a deep pit at the umbo.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Hypotype (pedicle valve 116800a) | 29.2 | 29.0 | 4.5 |
| “ (brachial valve 116800b) | 23.5 | 28.0 | 4.8 |

Types.—Holotype: G.S.C. 1161; paratypes: G.S.C. 1161a-d; figured hypotypes: 116800a,b,d; unfigured hypotype: 116800c.

Horizon and locality.—Rockland formation in Ontario, Canada: At Paquette Rapids; Bonnechère River, 1 mile below Eganville.

Discussion.—The specimens available for study are not very well preserved. The U. S. National Museum specimens are thin shelled and probably young forms. This may account for the small development of the muscle platforms. This species is proportionally wider than long and thus contrasts strongly with *O. canadensis* which is the reverse.

OBOLELLINA PARVA (Whitfield)

Dinobolus ? *parvus* WHITFIELD, Geol. Wisconsin, vol. 4, pl. 27, figs. 8-10, 1882.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 356, fig. 27, 1893.

This interesting species differs strongly from *O. dixonensis* particularly in details of the brachial valve. *Obolellina parva* has a fairly strongly developed and prominent median ridge extending anterior to the muscle platform. A trace of a median ridge is also present in the opposite valve. An impression of the brachial interior (45548a) shows a depression bounded by 2 short, low ridges, but the significance of this structure is not at once evident. It may be a depression similar to that in the brachial umbo of *O. magnifica*.

Types.—Holotype in the form of wax impressions of the two valves: 45548a,b.

Horizon and locality.—Prosser formation (*Fusispira* bed), Wykoff, Minn.

Family LINGULASMATIDAE Winchell and Schuchert, 1893

Linguoidal, corneous brachiopods with large internal platforms.

Genus LINGULASMA Ulrich, 1899

Lingulasma ULRICH, Amer. Geol., vol. 3, p. 383, 1889.

Most of the species of this genus found in lower Middle Ordovician rocks are generally imperfect. Many of the occurrences are found in vertical position in the rock, with the beak and platform regions badly crushed. As a consequence the apical region of both valves and the nature of the platforms of most species is still unknown. The character of the ornamentation with its rows of pustules or elevated dashes is generally very distinctive, and the variety of ornament makes specific splits possible on only small sections of the shell.

LINGULASMA COMPACTUM Cooper, new species

Plate 12, F, figures 18-21

Shell longer than wide, with subparallel sides and somewhat narrowly rounded anterior margin. Valves subequal in depth. Traces of platforms visible in crushed posterior third. Ornamentation distinctive, consisting of strong concentric undulations of growth; surface of sides and flanks covered by crowded, rounded, minute, wavy concentric lines but on body of shell in the median region the concentric elements become minutely discontinuous, the concentric ridges bearing granules arranged in radial rows. Radial elements only poorly developed on the flanks and along the margins, but on the median region the rows are closely crowded, about 7 in the space of a millimeter.

Measurements in mm.—Holotype, length 22.0, width 17.0, thickness 6.0 including both valves.

Type.—Holotype: 109347.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Discussion.—The specimen on which this species is based is somewhat better preserved than is usual for the genus. Unfortunately, the usual crushing of the beaks has taken place, but the outer shell showing the ornamentation is beautifully preserved. The species was somewhat more slender than any of those yet described in this country. The surface is most like that of *L. ? matutinum* in the strength of the concentric elements but differs in the more closely crowded radial rows of granules.

LINGULASMA MATUTINUM Cooper, new species

Plate 12, D, figures 9-11

Species based on fragments of three specimens. Sides subparallel and anterior margin broadly rounded. Valves subequal in depth and profiles. Interiors not preserved. Ornamentation consisting of fine, even, closely spaced, minutely wavy radial lines. Wavy lines with small granules arranged radially. Concentric lines closely crowded along the margins and with granules either not present or not preserved. Posteriorly radial and concentric elements becoming more or less merged to produce the appearance of a minutely beaded surface.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 19.6+ | 23.0 | 11.4 |
| Paratype (109348c) | 25.1+ | 22.4 | 12.2 |

Types.—Holotype: 109348a; figured paratype: 109348c; unfigured paratype: 109348b.

Horizon and locality.—Upper 25 feet of the Arline formation in Tennessee: In glade $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species suggests *L. compactum* but differs in its much larger size and coarser ornamentation.

LINGULASMA OKLAHOMENSE Cooper, new species

Plate 12, E, figures 12-17

Large, very thin shelled; outline subquadrate; longer than wide; lateral margins nearly parallel; anterior margin nearly straight; posterior margin narrowly rounded. Anterolateral extremities somewhat narrowly rounded. Valves unequally convex, the brachial valve having the greater depth. Anterior third of each valve flattened.

Ornamentation consisting of radiating lines of low elevations most distinct on the median portions and front of the valves but disappearing on the flanks, which are marked only by crowded undulations. Elevations consisting of narrow thread-

like ridges with their long axis arranged radially. Ridge with a long gentle slope on one side and a steep, precipitous face on the other, or a carina may occupy the middle of the elevation. Anterior side of the carina with a pit or gash, separating the elevation from the next anterior one. Asymmetrical elevations located mainly on sides of shell and with the long slope facing the lateral margin.

Brachial interior: Platform low; septum low and short.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 21.7+ | 19.0 | 8.4 ? |
| Paratype (109352e) | 27.5+ | 23.2 | 13.4 ? |
| " (109349a) | 28.6 | 25.2 | 11.8 |

Types.—Holotype: 109353b; figured paratypes: 109352d,e, 109353a; unfigured paratypes: 109349a, 109352a-c,f,g.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectia gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—This species differs from the two previously described species of this genus by its ornamentation and large size. The radial elevations of *L. gale-nense* are smaller and more distantly spaced than those of *L. oklahomense*. From *L. schucherti* the Oklahoma species is distinguished by the crowded concentric lines and absence of radial marking on the flanks. In *L. schucherti* the flanks are marked by crowded growth lines, and the radial elevations are more closely spaced. Furthermore, in *L. schucherti* the radial elevations are of different character from those of *L. oklahomense*, being more elongate at right angles to the radial direction and without the carina.

LINGULASMA OCCIDENTALE Cooper, new species

Plate 13, F, figures 13-17

Shell thin, of about medium size for the genus; apical angle about 90°; sides nearly parallel and straight; anterolateral extremities narrowly rounded; anterior margin very gently curved or nearly straight; pedicle valve with nearly flat lateral profile; brachial valve with gently convex lateral profile; surface marked by fine, concentric, minutely wavy lines and radial lines of minute granules.

Measurements in mm.—Holotype, length 18.4, width 16.2, thickness 6.2.

Types.—Holotype: 116793b; figured paratypes: 116793a, 117955; unfigured paratype: 117956.

Horizon and locality.—Yellow limestone above 25-foot sandstone of Eureka group in Nevada: 3 miles north of Martin Ranch on southwest side of hill 8167, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is suggestive of *L. matutinum* and *L. compactum* in the closely crowded concentric ornamentation but differs from both of the others in the greater degree of crowding and compaction of the ornamentation.

LINGULASMA sp. 1

Two specimens from the Oranda formation indicate a species not yet described. The ornamentation is quite unlike that of *L. compactum* but is more suggestive of *L. oklahomense*. These specimens have strong concentric lamellae on the posterolateral areas which are covered by fine, crowded, concentric lines and rows of granules. In the median and anterior portions of the shell the rows of granules are distant, about 4 to the millimeter.

Described specimens.—109354, 123303.

Horizon and locality.—Oranda formation in Virginia: Along the Southern RR. tracks $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle, and 0.4 mile west of U. S. Highway 11 on Virginia Highway 55, in the north edge of Strasburg, Strasburg (15') Quadrangle.

LINGULASMA sp. 2

This species, which is represented by the front end only, is the largest that has been found. The specimen measures 34.6 mm. in width. It is marked medially by distant rows of pustules, about 5 to the millimeter, but laterally it is marked by strongly crowded concentric lines and more closely spaced rows of pustules. The specimen was found in the lower portion of the Pinesburg member of the Shippensburg formation on U. S. Highway 40 at Wilson, 7 miles west of Hagerstown, Williamsport (15') Quadrangle, Md.

Described specimen.—123304.

LINGULASMA sp. 3

Shell small for the genus, perhaps a young specimen, somewhat rectangular in outline; sides subparallel; anterior margin nearly straight; anterolateral extremities narrowly rounded. Surface marked by distant concentric undulations over which are superimposed fine, crowded wavy lines and closely spaced rows of pustules.

Measurements in mm.—116794, length 15.8+, width 12.4, thickness 4.2+.

Described specimen.—116794.

Horizon and locality.—Edinburg formation (lower part of the middle of the *Nidulites* zone) in Virginia: Beside the road along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg, Strasburg (15') Quadrangle.

Discussion.—The ornamentation is very much like that of *L. compactum* in its crowded nature but differs in having more distant concentric undulations and a lesser development of the pustules.

Genus LINGULOPS Hall, 1871

LINGULOPS CLIFTONENSIS Foerste

Plate 23, C, figures 5, 6

Lingulops cliftonensis FOERSTE, Journ. Geol., vol. 11, p. 38, 1903.

Figures of this species are introduced to show the extent of development of the platform in the brachial valve of *Lingulops*. Compare with *Elliptoglossa* and *Lingulops norwoodi* on the same plate.

Holotype.—78667.

Horizon and locality.—Fernvale formation, Clifton, Tenn.

LINGULOPS NORWOODI (James)

Plate 23, A, figures 1-3; plate 23, B, figure 4

For complete synonymy see Bassler, U. S. Nat. Mus. Bull. 92, p. 741, 1915.

Figures of this species are introduced to show a form with more modest development of the platform in the brachial valve. The figures also show specimens of the same species with varying development of this species. Compare all with *Elliptoglossa*.

Figured specimens.—15863a, 45219a,b.

Horizon and locality.—Upper part Trenton formation, Ludlow and West Covington, Ky.

Family PATERULIDAE Cooper, new family

Subcircular to elliptical, corneous shells, lenticular in profile; sides with flattened rim; pedicle valve with pedicle notch or shallow pedicle groove.

This family consists mainly of small, scalelike shells which although common enough from the Ordovician through the Devonian, are very poorly understood. In some places these shells occur in countless numbers. They are so unlike brachiopods in some respects that one of the genera was suggested to be a gastropod (Sardeson, 1931, p. 353). However, specimens of *Craniops* are known, and one is illustrated herein, with both valves in contact showing that the genus is really a bivalved form and by its symmetry and musculature is undoubtedly a brachiopod. The genus *Paterula* commonly occurs in black shales or in limestones associated with black shale. *Elliptoglossa* is less well known, but it too occurs in black shale or in bituminous limestones. *Craniops*, on the other hand, is a common associate of normal shelly faunas.

Genus PATERULA Barrande, 1879

Paterula BARRANDE, Syst. Sil. Centre Boheme, vol. 5, p. 110, 1879.

Paterula Barrande, DAVIDSON, General summary to British fossil Brachiopoda, p. 391, 1884.

Paterula Barrande, HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 78, 1893.

Shell minute, polished brown, cream yellow or black, inequivalved, the brachial valve having the greater depth; subcircular to oval in outline. Pedicle valve flat to gently convex in profile; brachial valve moderately to strongly convex. Surface ornamented by concentric lines and undulations of growth.

Inside of both valves provided with a more or less wide, flattened border like that of *Elliptoglossa* and an inner narrowly elevated border surrounding the visceral cavity. Pedicle valve with a posterior pedicle groove and notch; brachial valve with margin unnotched. Inside the pedicle valve 2 slightly divergent impressed lines extend from a point just anterior to the pedicle notch anteriorly to about the middle of the valve. These lines terminate on each side of a large, round muscle scar. Anterior to the circular scar numerous pallial impressions radiate anteriorly, anterolaterally and laterally. Small scars occur on the anterolateral

sides of the central scar and also a short distance posterolaterally of the central scar. Two pits appear on each side of the median line and just anterior to the pedicle notch, and anterolateral to these and close to the margin occur another pair of muscles.

The brachial valve is characterized by a strong and deep umbonal muscle pit. From this pit 2 pallial trunks extend anterolaterally for about one-third the length of the valve. Two small muscle scars are located near the center, but other scars are obscure.

Genotype.—*Paterula bohémica* Barrande, Syst. Sil. Centre Bohême, vol. 5, p. 110, pls. 95, 152, 1879.

Discussion.—Little has been known of this peculiar genus because its shells are generally very rare. Until the present writing a single species, *P. amii*, was known in North America. Excellently preserved specimens occur in many parts of the Southern Appalachians from Alabama to Pennsylvania which afford new information on the genus. Unfortunately, the specimens are so small and the muscle marks so faintly impressed that description of the interior is difficult.

One of the most striking features of the pedicle interior is the occurrence of a fine impressed line originating just anterior to the pedicle notch. This line divides, and the 2 branches extend anteriorly to about the middle of the valve. Anterior to the end of these lines occurs a network of minute pallial impressions that radiate anteriorly, anterolaterally, and laterally.

The muscle system of the pedicle valve is difficult to establish, but it seems certain that the following are present: 2 small umbonal muscles, a large central one, 2 pairs of small muscles occurring anterolateral and posterolateral to the central one, and a pair or 2 pairs anterolateral to the pedicle notch and located just under the margin.

The interior of the brachial valve is less clearly defined in the specimens available. The big umbonal muscle patch with the 2 short but prominent pallial trunks diverging from it are the most striking features.

In the rocks under consideration *Paterula* occurs rarely in the Arline formation but it is common in the Botetourt and Oranda formations. It occurs in the Liberty Hall facies, and two specimens are known from the Trenton of New York. The genus has been taken in the Bromide and Viola formations of Oklahoma. It is thus evident that it may be expected in any rocks from Black River to high Trenton. The genus is most abundant in bituminous limestones or limestones associated with black shales such as those of the Botetourt, Oranda, and Liberty Hall facies between Harrisonburg and Winchester, Va. Specimens are very abundant in the Pratt Ferry formation at Pratt Ferry, Blocton Quadrangle. These limestones yield large numbers of specimens when the blocks are dissolved in acetic acid. The Botetourt limestone in the vicinity of Strasburg, Va., yields free specimens on etching with hydrochloric acid. The same treatment will yield small numbers of specimens from various parts of the *Nidulites* zone of the Edinburg formation.

The genus also occurs in abundance in limestones of the Table Head forma-

tion, Newfoundland, and the Quebec City formation in Quebec, Canada. The earliest species is from the *Shumardia* zone of Quebec.

PATERULA AMII Schuchert

Paterula sp. HALL and CLARKE, Pal. New York, vol. 8, p. 78, pl. 4, K, fig. 1, 1893.

P. amii SCHUCHERT, U. S. Geol. Surv. Bull. 87, p. 301, 1897.—REUEMANN, New York State Mus. Bull. 42, p. 569, pl. 1, fig. 2, 1901.

Horizon and locality.—Quebec City formation: South of St. Johns Market, Quebec, Province of Quebec, Canada. Normanskill formation: Mount Merino, near Hudson, N. Y. Humber Arm series, Newfoundland.

PATERULA PERFECTA Cooper, new species

Plate 18, H, figures 54-56; plate 24, D, figures 12-23

Shell small, inequivalved, subelliptical in outline. Anterior and posterior margins slightly more narrowly rounded than the lateral margins. Surface of both valves ornamented by fine concentric undulations and very obscure and fine radial lines.

Pedicle valve gently convex in profile with the greatest convexity at the posterior third; beak submarginal, smooth, pedicle notch small.

Brachial valve strongly convex in profile with the greatest convexity a little posterior to the middle. Beak obscure, smooth, located a little less than one-fifth the length of the valve from the posterior margin. Posterior slope steep and gently concave; anterior slope gentle and convex. Lateral slopes moderately steep but flat.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Paratype (pedicle valve 116799a) | 3.1 | 3.0 | 0.5 |
| " (" " 109409c) | 2.0 | 1.8 | ? |
| " (brachial valve 109409d) | 2.5 | 2.1 | 0.6 |

Types.—Holotype: 109409k; figured paratypes: 109404c-e, g, 109407, 109409c, h, i, o-q, 116799a-c, 109408a; unfigured paratypes: 109404a, b, f, 109406a-e, 109408b, 109409a, b, d-g, j-n.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Limestone in the base of the Whitesburg formation in Tennessee: 1½ miles west of Bulls Gap, and 2 to 2½ miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle. Arline formation in Tennessee: ½ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Botetourt formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; 4 miles southwest of Bland, Bland County; 1½ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle; 1 mile northeast of Harrisonburg; ½ mile west of Strasburg, Strasburg (15') Quadrangle.

Botetourt formation (*Cybeloides* bed) in Virginia: Opposite the dam on the Shenandoah River, 1 mile north of Edinburg, Edinburg (15') Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: $1\frac{1}{2}$ miles south of Wadesville, Winchester (15') Quadrangle; opposite the bridge at Riverton, Front Royal (15') Quadrangle.

Oranda formation in Virginia: 4 miles northwest of Linville Station, Broadway (15') Quadrangle.

Discussion.—This species is common in the Liberty Hall facies of the Edinburg formation and in limestones associated with the black shale in Alabama, especially at the base. The most nearly comparable species is the small *P. polita* from the Viola formation of Oklahoma. The latter is smaller and somewhat more oval and with less convexity to both valves.

PATERULA POLITA Cooper, new species

Plate 24, A, figures 1, 2

The known specimens of this species are somewhat smaller than those of *P. perfecta*, but there are a number of more important differences between the two species. The pedicle valve of *P. polita* is more narrowly rounded at the posterior and with a much smaller pedicle opening than in *P. perfecta*. The brachial valve of *P. polita* is much less convex than the same valve of *P. perfecta*.

Measurements in mm.—

| | Length | Width | Thickness |
|---------------------------------|--------|-------|-----------|
| Holotype (pedicle valve) | 1.9 | 1.6 | ? |
| Paratype (brachial valve) | 1.7 | 1.5 | 0.3 |

Types.—Holotype: 109411b; paratype: 109411a.

Horizon and locality.—Viola formation (lower), in Oklahoma: SE $\frac{1}{4}$ sec. 32, T. 2 S., R. 2 E., 3 miles north-northeast of Springer, Murray County.

Discussion.—For differences from *P. perfecta* see p. 238.

PATERULA SUBCIRCULARIS Cooper, new species

Plate 24, C, figures 7-10

Shell fairly large for the genus, nearly circular in outline, the anterior margin somewhat more narrowly rounded than the posterior margins and producing a slightly oval outline. Surface marked by concentric undulations. The pedicle valve is gently convex in profile with the maximum convexity at about the middle where the valve is slightly swollen. Pedicle notch narrow and deep. Lateral border narrow on all margins, but widest on the posterolateral extremities.

Brachial valve much like the pedicle valve and having nearly the same convexity. All borders narrow but the posterior one wider than the others.

Measurements in mm.—Brachial valve (paratype 109414c), length 4.1, width 3.6.

Types.—Holotype: 109414b; paratypes: 109414a,c.

Horizon and locality.—Stringtown shale = Womble shale (Big Fork chert) in Oklahoma: Near the center of sec. 29, T. 1 S., R. 12 E., on south bank of north Boggy Creek, near base of exposure, southwest of Stringtown, Atoka County;

sec. 28, T. 3 N., R. 20 E., Latimer County; Round Prairie, Potato Hills, Latimer County.

Discussion.—This species can be recognized by its large size relative to the others described and by its nearly circular form. The three specimens on which the species is based vary in size but indicate a species in which the two valves were nearly equal in convexity. In its form and subequal convexity, this species differs from the others herein described.

Genus **CRANIOPS** Hall, 1859

CRANIOPS ATTENUATA Cooper, new species

Plate 22, A, figure 1

Craniops HALL, 12th Rep. New York State Cab. Nat. Hist., p. 84, 1859.

Shell large for the genus, oval in outline, widest slightly posterior to the middle but narrowing anteriorly; posterior margin more broadly rounded than the anterior one; apex located about one-fifth the length from the posterior margin; anterior slope gently convex, long and sloping gently to the anterior margin; posterior slope short, steep, and gently concave. Surface smooth except for growth plaits which are distant and number 8 or 9. These are distant in the median region but crowded in the posterolateral areas.

Measurements in mm.—Holotype, length 4.9, width 3.8, height 1.1.

Type.—Holotype: 116798.

Horizon and locality.—In Alabama (near the top of the massive limestone) Carters formation: Quarry 0.3 miles north of Gate City, Leeds (15') Quadrangle.

Discussion.—This is a large species having a length slightly in excess of *C. trentonensis* (Hall) to which it may be compared. It differs from that species in having an attenuated anterior margin and in the apex being located farther forward of the posterior margin.

CRANIOPS MINOR (Winchell and Schuchert)

Pholidops trentonensis minor WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 376, pl. 29, fig. 40, 1893.

Horizon and locality.—Decorah formation (Guttenberg member-*Ctenodonta* bed, Ion member-*Phylloporina* bed), and Prosser formation (*Clitambonites* and *Nematopora* beds) in Minnesota.

CRANIOPS TENUIS Cooper, new species

Plate 22, C, figures 3-5

Shells thin, small, often both valves in contact; longitudinally elliptical to sub-oval in outline with the posterior slightly wider than the anterior. Lateral and posterior margins broadly rounded but anterior margin slightly more narrowly rounded than the posterior one. Valves subequally convex, the pedicle valve slightly less convex than the brachial and with the beak situated slightly anterior to that of the brachial valve. Brachial lateral profile with a bulge produced by

a median swelling. Pedicle posterior slope more gentle than the brachial one. Beaks directed posteriorly, umbones small, narrowly rounded, and slightly elevated. Both valves marked by fine concentric lines and a few distant concentric growth lamellae.

Measurements in mm.—Holotype, length 2.2, width 2.0, thickness 0.7.

Types.—Holotype: 109752a; unfigured paratypes: 109752b-1.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectia gouldi* zone), in Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E.; on a branch of Hickory Creek in NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., Criner Hills, Carter County. Two specimens are placed here that come from the Bromide formation (Mountain Lake member) at the Rock Crossing of Hickory Creek, and midway between Davis and Dougherty, NW $\frac{1}{4}$ sec. 27, T. 1 S., R. 1 E., Murray County.

Discussion.—This species by its small size suggests *C. minor* (Winchell and Schuchert) but differs in its still smaller size, less oval outline, and much fewer growth plaits. It is a far smaller shell than *C. trentonensis* Hall and will not be confused with it.

CRANIOPS TRENTONENSIS (Hall)

Plate 22, B, figure 2

Pholidops trentonensis HALL, Descr. new species Crinoidea and other fossils, p. 14, 1866; 24th Ann. Rep. New York State Cab. Nat. Hist., p. 221, pl. 7, fig. 8, 1872.—BASSLER, U. S. Nat. Mus. Bull. 92, p. 969, 1915.

Nealmont formation in Pennsylvania: Reedsville, Lewistown (15') Quadrangle. The collection from which the specimens were taken includes such genera as *Pionodema* which indicates clearly that these "Stones River" beds must belong to the Nealmont formation and therefore must be of Trenton age. The nearly circular form of the shell, its large size, and the distant plaits are features that it shares with *C. trentonensis*. It is of about the same size as *C. attenuata*, but that species is narrowed anteriorly.

Figured specimen.—109788b.

ELLIPTOGLOSSA Cooper, new genus

(Greek *ellipto*, elliptical; *glossa*, tongue)

Shell small, longitudinally elliptical in outline with anterior and posterior margins subequal, depth of valves subequal; surface marked by fine concentric lines and concentric undulations. Radial markings present in some species.

Pedicle interior: Outer margin smooth and flattened along the line of valve junction; posterior margin broadly flattened and marked medially by a narrow depression, probably a pedicle groove. Pedicle attached to a small roughened area at the extreme posterior. Musculature suggesting *Lingula* but not identical with it. The umbonal muscle (or muscles) the most strongly impressed, but the external, central, and middle muscle scars discernible. The large laterals of *Lingula* apparently are absent. The visceral region forms a crudely trapezoidal area with the lateral angles formed by oblique, hooklike impressions. A low ridge extends from the umbonal muscle to a point anterior to the center.

Brachial interior: Umbonal and external muscles along the median line usually clearly visible but additional musculature not yet identified. Margins flattened.

Genotype.—*Leptobolus* ? *ovalis* Bassler = *Elliptoglossa ovalis* (Bassler), Cambrian and Ordovician: Geol. Surv. Maryland, p. 230, pl. 49, figs. 14-16, 1919.

Discussion.—The members of this interesting little genus can be identified by their longitudinally elliptical or narrowly oval outline, the broad and flat outer rim, and the absence of a clearly defined pedicle groove.

Elliptoglossa most closely resembles the peculiar genus *Lingulops* which is regarded by some brachiopod students as one of the earlier members of the Trimerellidae. Like *Lingulops* the genus under consideration has the same external form and the same type of flattened contact surface bounding the visceral region. Another striking analogy is in the faint groove marking the median portion of the posterior border, which is regarded as a pedicle groove. The interior of *Lingulops* is, however, unlike that of *Elliptoglossa*. The muscles of the latter are not so clearly impressed, and no tendency to the development of a platform at the anterior end of the muscle field has been detected. Inasmuch as the external form and ornamentation of *Elliptoglossa* and *Lingulops* are alike and their musculature is similar, it is possible that the latter was derived from the former.

In its possession of a flattened brim surrounding the valves, *Elliptoglossa* is suggestive of *Paterula*, but the two should not be confused because the pedicle valve of the latter genus has a distinct notch and the valves are usually unequal in depth. The brachial valve of *Paterula* is usually deeper and more convex than that of the pedicle valve. Another feature distinguishing the two genera is that of external shape: *Elliptoglossa* in all its known species is elongate whereas the valves of *Paterula* are generally subcircular to suboval, the little tapering present taking place in an anterior direction.

Elliptoglossa appears first in the *Shumardia* zone of the Lévis formation high in the Canadian where it is represented by *Paterula westoni* Clarke. This is a large species, but it has all the characters of the new genus. A similar species occurs in the Quebec City formation at Quebec. It also occurs in abundance in the Pratt Ferry formation at Pratt Ferry, Ala., where it can be etched from the limestone by acetic acid. The genotype species occurs in the *Sinuities* beds at the base of the Martinsburg shale in Pennsylvania. *Elliptoglossa* is again encountered in the Botetourt formation of Virginia and Tennessee and ranges into the Oranda formation where it is common. One fine species occurs in the high Ordovician (Maquoketa) of Missouri and the Sylvan shale of Oklahoma.

ELLIPTOGLOSSA OVALIS (Bassler)

Plate 23, E, figures 14-26

Leptobolus ? *ovalis* BASSLER, Cambrian and Ordovician: Geol. Surv. Maryland, p. 230, pl. 49, figs. 14-16, 1919.

Shell small, longitudinally oval in outline with the posterior margin slightly narrower than the anterior margin. Anterior and posterior margins narrowly

rounded. Maximum width at the middle. Sides moderately curved. Valves marked by even, concentric lines.

Pedicle valve evenly and broadly convex in lateral profile with the maximum convexity located at the middle; anterior profile narrowly convex. Valve swollen medianly, with steep lateral slopes but a more gentle anterior slope. Apical angle 90° to 100° . Posterior slope long and gentle. Umbo small, short, narrowly swollen.

Brachial valve somewhat more rounded than the pedicle valve and less convex in anterior and lateral profiles. Inner border of both valves fairly wide, but widest at the posterior.

Measurements in mm.—

| | Length | Width |
|--------------------------|--------|-------|
| Lectotype | 5.7 | 3.7 |
| Paratype (109357e) | 4.0 | 2.5 |

Types.—Lectotype: 66171a; figured paratypes: 66171c (b,e, Bassler, 1919); unfigured paratype: 66171d; figured hypotypes: 109357b-e,f, 109370a, 109371a,b, 109378a, 109379a, 109380.

Horizon and locality.—Martinsburg formation (base of *Sinuities* bed) in Pennsylvania: 2 miles northwest of Kauffman, Chambersburg (15') Quadrangle; along the railroad south of highway crossing, $2\frac{1}{2}$ miles southwest of Marion, Chambersburg (15') Quadrangle.

Oranda formation in Pennsylvania: 1 mile south of St. Thomas, Mercersburg (15') Quadrangle; 2 miles southeast of Mercersburg, Mercersburg (15') Quadrangle; just north of Chambersburg and 5 miles south-southwest of Chambersburg, Chambersburg (15') Quadrangle.

Botetourt formation in Virginia: 4 miles southwest of Bland: Hoge Farm, 6 miles southwest of Bland; near Lusters Gate, 3 miles (airline) east of Blacksburg, Blacksburg (15') Quadrangle; 2 miles northeast of Blacksburg, Blacksburg (15') Quadrangle; 1 to 2 miles west of Lexington, Lexington (15') Quadrangle; $1\frac{1}{2}$ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle; on the boundary of the George Washington Forest, 1.8 miles south-southwest of Bethel Church, 6 miles (map measure) due east of Harrisonburg, Harrisonburg (15') Quadrangle.

Botetourt formation in Tennessee: 2 miles south of Albany, Mosheim (T.V.A. 181-NW) Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: 2 miles southwest of Broadway, Broadway (15') Quadrangle; just northwest of Lee Highway at Lacey Springs, Broadway (15') Quadrangle; 300 feet north of U. S. Highway 60, 1 mile north of the railroad station at Lexington, Lexington (15') Quadrangle; $1\frac{1}{2}$ miles northeast of Harrisonburg on Lee Highway (U. S. 11), Harrisonburg (15') Quadrangle; $1\frac{1}{2}$ miles east of Tenth Legion, Mount Jackson (15') Quadrangle; 1 mile due west of Hollins, Roanoke (15') Quadrangle; $1\frac{1}{2}$ miles south of Wadesville, Winchester (15') Quadrangle.

Effna formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Oranda formation in Virginia: 4 miles northwest of Linville Station, Broadway (15') Quadrangle.

Whitesburg formation in Tennessee: 2½ miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Discussion.—This species is characterized by its elongate oval form with narrowly rounded extremities and fairly wide inner borders. The specimens are usually lustrous black in color but may weather to a reddish hue as southwest of Bland, Va. Interior details are very difficult to determine.

Elliptoglossa ovalis differs from *E. sylvanica* in its sharper beaks, more elongated form, and narrower extremities.

ELLIPTOGLOSSA ROTUNDATA Cooper, new species

Plate 24, B, figures 3-6

This species may be distinguished from *E. ovalis* by its proportionately rounder anterior and posterior margins, more rounded sides, and stronger concentric undulations. The same features distinguish it from *E. sylvanica* although with the latter species the differences are not so striking.

Measurements in mm.—Holotype, length 5.0, width 3.6.

Types.—Holotype: 71885a; figured paratypes: 109386a, 71885c,d; unfigured paratypes: 71885b,e-m, 109386b-d.

Horizon and locality.—Edinburg formation (Liberty Hall facies) in Virginia: On Middle River, ½ mile north of Verona, Staunton (15') Quadrangle; 500 feet northwest of the entrance to Endless Caverns, Mount Jackson (15') Quadrangle; Reservoir Hill, Wytheville; 2 miles northeast of Dale Enterprise, Harrisonburg (15') Quadrangle; Lee Highway, 1½ miles northeast of Harrisonburg, Harrisonburg (15') Quadrangle; 1½ miles east of Tenth Legion, Mount Jackson (15') Quadrangle.

Rich Valley formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

ELLIPTOGLOSSA SYLVANICA Cooper, new species

Plate 23, D, figures 7-13

Shell small, lustrous with alternating bands of light and darker brown, a little longer than wide and with the greatest width at about the middle. Sides gently rounded; posterior and anterior margins about equally rounded. Umbonal region minutely radiate. Surface marked by fine concentric undulations.

Pedicle valve moderately convex in lateral profile; strongly convex in anterior profile and with the flanks gently concave in this profile. Brachial valve slightly deeper than the pedicle one, a little more convex in lateral profile; flanks flattened.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (brachial valve) | 4.0 | 2.8 | 0.5 ? |
| Paratype (pedicle valve 109388a) | 3.8 | 2.4 | ? |
| “ (brachial valve 109388c) | 3.4 | 2.5 | ? |

Types.—Holotype: 109388e; paratypes: 109388a,b,f-i, unfigured paratypes: 109388c,d.

Horizon and locality.—Sylvan shale (lower 40 feet) in Oklahoma: Middle east side sec. 34, T. 1 S., R. 2 E., Murray County, Arbuckle Mountains. Maquoketa chert in Missouri: Decaturville, Camden County.

Discussion.—This species differs from *E. ovalis* in its rounder form, somewhat deeper and more convex valves and the narrower flattened margins, particularly the posterior margin. On the exterior the minutely radiate umbo is distinctive. Details of the interior of this species are also very difficult to determine because of the thin shell.

Superfamily ACROTRETACEA Schuchert, 1896

Family ACROTRETIDAE Schuchert, 1913

Approximately circular shells with more or less elevated conical pedicle valves with small, simple pedicle opening.

Subfamily ACROTRETINAE Matthew, 1903

Usually small shells with high conical pedicle valves having a small postapical foramen; brachial valve with marginal beak.

Identification of the genus *Acrotreta* is difficult and uncertain because the interior details of the genotype are still unknown. The type species is known to come from Ordovician rocks, a fact that may exclude many of the Cambrian species referred to this genus. It is possible, too, that if the type species of *Acrotreta* comes from the Kunda formation, it may actually have the same structure as *Conotreta* which occurs in rocks of the same age. This point, too, cannot be settled until the interior of the type species is known.

Solution of limestone in acetic acid has opened a new vista in the study of these small and difficult shells. The Pratt Ferry limestone, Alabama, has proved very prolific of a variety of acrotretids having complicated and unusual structures. It is probable that the same methods applied to other bituminous limestones will produce a still greater variety of forms. This is proving to be true in the Cambrian, from which a variety of novel forms has been taken.

Genus ACROTRETA Kutorga, 1848

Acrotreta KUTORGA, Verhandl. Russ.-Kais. Min. Ges. St. Petersburg, for 1847, pp. 260, 275, 1848.

ACROTRETA GEMMA Billings

Plate 22, E, figures 10, 11

Acrotreta gemma BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 216, figs. 201a-f, 1865.—WALCOTT, U. S. Geol. Surv. Mon. 51, p. 685, pl. 66, figs. 1a, b, 1912.

One specimen of two present in the National Collection is worthy of remark. Both are pedicle valves, and one of them seems to be a perfectly normal individual with a pseudointerarea and intertrough as described by Billings and Walcott. The second specimen has a perfectly formed pseudointerarea, but the median part of that surface is elevated to form a gradually widening ridge from beak to base. The structure suggests the homoeodeltidium of the Paterinacea. The structure is too regular to be a deformity, but more specimens are needed to understand it.

Figured specimen.—116816a.

Horizon and locality.—Upper Table Head series in Newfoundland: At Table Point Cove.

ACROTRETA MAGNA Cooper, new species

Plate 28, D, figures 9-12

Shell large for the genus, forming a depressed cone in profile; outline subelliptical; surface marked by fine concentric elevated lines.

Pedicle valve forming a posteriorly truncated cone in lateral profile; anterior slope long and moderately convex; beak posterior to the center; posterior slope shorter than the anterior one, very steep and gently convex. Anterior profile broadly convex and with convex sides. Apical angle 75° ? Pseudointerarea broad; intertrough narrow and deep.

Brachial valve elliptical in outline with the width slightly greater than the length; hinge wide and straight; posterolateral extremities narrowly rounded; sides gently rounded and anterior broadly rounded. Lateral profile gently convex, with the maximum convexity in the umbonal region; anterior portion flattened; anterior profile broadly convex with the maximum convexity at the middle; lateral slopes long and gently concave. Median septum extending from the posterior margin to about the middle of the valve; 2 large muscle scars located on each side of the median ridge just anterior to the hinge are visible.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 5.5 | 6.8 | 2.7+ |
| Paratype (brachial valve 109724b) | 8.3 | 6.4 | ? |

Types.—Holotype: 109724a; figured paratype: 109724b; unfigured paratypes: 109724c-f.

Horizon and locality.—Boulders of the Mystic conglomerate in Quebec, Canada; Range 6, Lot 20, $2\frac{1}{2}$ miles north of Mystic, Stanbridge Township.

Discussion.—This species has been assigned to *Acrotreta* rather than to *Conotreta* because of its earlier age than *Conotreta* and because only the bases of 2 pallial trunks could be distinguished. The extreme inner ends of the pallial trunks only are visible, and no evidence of branching could be seen. Actually it cannot be determined whether or not the trunks do branch.

If this species does belong to *Acrotreta*, it is a fairly large form for the genus. It is characterized by its depressed conical form and the low convexity of the brachial valve. It is suggestive of *Conotreta depressa* but is a somewhat more elevated cone than that form.

Genus CONOTRETA Walcott, 1889

Conotreta WALCOTT, Proc. U. S. Nat. Mus., vol. 12, p. 365, figs. 1-4, 1890 (extracts 1889).

The name *Conotreta* has long been known, but it has been applied to a single species in this country. A few other species are known in Europe, but until this study was undertaken the genotype was the only one known in this country. In the description of the genus, Walcott made known the pedicle valve only. Discovery of abundance of mineralized specimens in the Liberty Hall facies near Lacy Spring, Va., and the limestone at Pratt Ferry, Ala., makes it possible to describe and illustrate some fine interiors.

The pedicle valve is an irregular cone, the posterior side of the cone flattened by the pseudointerarea but the anterior side usually convex. The posterior side with the pseudointerarea is usually shorter than the anterior side. The side facing the brachial valve is thus oblique. The beak is small and usually smooth and slightly curved in a posterior direction. It may, however, be bent slightly anteriorly as in *C. plana* described below. The foramen is minute and is located very slightly posterior to the apex. The pseudointerarea often is simply a flattened triangular area on the posterior face, ornamented in the same manner as the rest of the valve. More often, however, it shows a slightly elevated central track defined by shallow grooves down which a more or less shallow impressed line extends. This impressed line is the intertrough, and it may extend from the foramen to the margin or may be visible for a short distance only. Its function is uncertain. In exfoliated specimens the intertrough shows more clearly. In such specimens the median swollen portion of the palintrope is well shown and is bounded by 2 grooves that represent slight thickenings or depressions that help to support the portion of the palintrope that covers the pedicle region.

The foramen, although minute, leads into a pedicle groove of considerable size that widens toward the brachial valve and opens into the interior posterior to a pillar or boss of vesicular shell used to strengthen the apical region as the valve grows. The pedicle aperture inside the valve is many times larger than the foramen. The base of the pedicle was probably attached to the posterior surface of the pillar.

One of the features that gave *Conotreta* generic status is the great development in size and number of the pallial trunks in the pedicle valve. The 2 primary trunks, corresponding to the vascula media of Öpik, originate on each side of the pillar and by the depth of their insertion into the shell substance make the pillar stand into bold relief. The major trunks branch more or less numerously, chiefly by bifurcation, and may produce as many as 7 trunks on each side.

The musculature of the pedicle valve is difficult to determine, but two specimens from the Liberty Hall facies show a pair of muscles located on each side of the valve posterolaterally to the pedicle groove. The larger scar is located farthest from the groove. One of these pairs probably corresponds to the cardi-

nal scar figured by Walcott in "*Acrotreta*." Alabama specimens show large scars just inside the posterior margin on the underside of the palintrope.

Brachial interior: The etched specimens from the Liberty Hall facies show the interior of the brachial valve to perfection. The posterior quarter is thickened to form a platform. At the apex a small triangular groove occurs that may have served as a seat of muscle attachment. Just anterior to the groove and at each angle occurs a large elliptical muscle scar. Inside these scars and at their anterior end appear 2 small muscle scars. At the anterior end of the thickened platform a thin elevated median ridge rises to a point slightly anterior to the middle and then descends rapidly to the floor of the valve. The 4 muscle scars are the only ones determined with certainty. It is possible that the median septum also was a seat of muscle attachment, but no marks were seen on it to bear out this suggestion. The large scars are the cardinals of Walcott, but no scars were seen anterior to the posterior platform that could be interpreted as the centrals of Walcott.

Conotreta is common in the Botetourt and Pratt Ferry formations and the carbonaceous limestones of the Liberty Hall facies in the belt between Harrisonburg and Winchester, Va. Only one species of *Conotreta* is so far known from pre-Botetourt rocks in the Appalachians. Elsewhere specimens having the outer form of *Conotreta* are referred to the genus *Acrotreta*.

Conotreta cannot be regarded as a well-established genus until the internal characters of *Acrotreta* are thoroughly known. The latter occurs in rocks equivalent to those of the Black River-Trenton interval in Estonia, but its internal characters are not clearly known. The bases of 2 pallial trunks are visible in one of the types, but the extent to which they branch is unknown. It is thus possible that *Acrotreta* and *Conotreta* are synonyms, but the point cannot now be settled.

CONOTRETA ? ALTA Cooper, new species

Plate 16, A, figures 1-3

This species differs from all others known from Chazyan rocks by its very narrow form and the great elevation of the pedicle valve. This species has an apical angle of 30° and a lateral angle of 26° . It is thus the narrowest form known. The pseudointerarea is narrow, but the intertrough is located on a low, longitudinal elevation along the center of the pseudointerarea. Surface marked by very fine concentric lines. The holotype lacks the apex but is 1.9 mm. long along the anterior slope and 1.2 mm. long on the posterior face, width 1.7 mm.

Type.—Holotype: 109715.

Horizon and locality.—Arline formation in Tennessee: In glade $\frac{1}{4}$ mile south-east of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

CONOTRETA ? ALTIROSTRA Cooper, new species

Plate 18, G, figures 51-53

Shell small, long and slender, forming a slightly curved cone obliquely open at the anterior end. Pedicle valve a slender cone with gently curved posterior

margin and moderately convex anterior margin; anterior profile with gently concave sides; apical angle 35° to 40° ; apex truncated, perforated by a minute foramen. Pseudointerarea broad and flat; intertrough narrow and extending for the length of the valve.

Measurements in mm.—Holotype, length 1.5, width 2.0, thickness 3.5.

Type.—Holotype: 116812.

Horizon and locality.—Botetourt formation in Virginia: Field on the south side of the road, 0.2 miles east of Strasburg Junction station, Strasburg (15') Quadrangle.

Discussion.—This species is distinguished from all the other conical forms described by the extreme thickness or elongation of the valve in the direction of the thickness. The beak is long and slender and the sides of the valve concave. It is probable that this form and *C. alta* belong to a new genus. Correct assignment will have to await the discovery of the brachial valve.

This species is suggestive of *C. ? alta* but differs in its larger size and the slight curvature of the pedicle valve in lateral profile.

CONOTRETA APICALIS Cooper, new species

Plate 17, B, figures 15-28

Shell of about medium size for the genus, thick, dull dark brown in color; obliquely conical in outline with the posterior side flattened; shell margin nearly circular; height or thickness equal to the width. Surface marked by growth undulations and fine concentric lines.

Pedicle valve with apical angle of 43° ; lateral profile with strongly convex anterior margin; anterior profile with slightly convex lateral margins; beak acutely pointed; foramen minute, apical. Posterior margin in lateral profile gently concave; width of pseudointerarea about half the valve width.

Brachial valve slightly longer than wide; gently convex in lateral profile with the greatest convexity located in the anterior part of the posterior third of the valve; anterior two-thirds somewhat flattened; anterior profile broadly convex, somewhat flattened medially and with short, gently sloping lateral slopes.

Pedicle interior: Foraminal cavity deep; pallial sinuses numbering 3 on each side; callosity just anterior to foraminal cavity small. Brachial interior with short and narrow triangular depression; propareas small; median ridge extending nearly to front margin, highest about one-half the length anterior to the posterior margin where it attains a sharp point. Posterior part of septum with a crescent-shaped smooth area located just anterior to the triangular depression.

Measurements in mm.—

| | Length | Width | Thickness |
|------------------------------------|--------|-------|-------------------------|
| Holotype (pedicle valve) | 3.1 | 3.4 | 3.1 (posterior surface) |
| Paratype (brachial valve 116813c). | 2.5 | 2.6 | ? |

Types.—Holotype: 116813a; figured paratypes: 116813b-g.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is suggestive of *C. gigantea*, but it is generally a thicker shell, more slender, and with a smaller apical angle. It is an uncommon species in the insoluble residues from Pratt Ferry.

CONOTRETA ? CONCENTRICA Cooper, new species

Plate 18, C, figure 22

Shell fairly large for the genus, represented by the pedicle valve only. Nearly symmetrically conical in profile with the apex subcentral; lateral profile with gently convex anterior slope and long steep, nearly flat posterior slope. Anterior profile conical with gently convex sides; apical angle obtuse. Foramen apical, minute. Apical half of shell marked by very fine concentric growth lines; anterior half marked by strong, regular, elevated concentric ridges which do not extend over the pseudointerarea; pseudointerarea broad and flat; intertrough not clearly discernible. Interior without visible structures. Accurate measurements not possible.

Type.—Holotype: 116814.

Horizon and locality.—Lower 3 feet of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This is the only species assigned to *Conotreta* which has strong marginal corrugations. The ornamentation thus suggests that of *Scaphelasma*, but the other features are quite different. It was not possible to ascertain the interior structure; no apical callosity like that of *Conotreta* was seen, and it is probable that this specimen represents a new genus. Until the brachial valve is known, it is not possible to understand the true relationships of the genus.

CONOTRETA CUSPIDATA Cooper, new species

Plate 16, B, figures 4-7

Shell of moderate size; pedicle valve nearly circular in outline, lateral profile a narrow wedge. Pseudointerarea triangular, occupying a little more than one-third the width. Apical angle 60° ; lateral angle 50° . Beak bent very slightly posteriorly. Surface ornamented by concentric, low undulations and fine concentric lines.

Brachial valve almost circular, but with the posterolateral margins somewhat shouldered; very gently convex in lateral profile. Median sulcus shallow and narrow, practically obsolete at the front margin.

Measurements in mm.—Pedicule valve (109716a), posterior slope 2.5, anterior slope 3.3, width at base of cone 3.1. Brachial valve (109716b), length 3.0, width 3.3.

Types.—Holotype: 109716a; paratype: 109716b.

Horizon and locality.—Effna formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—See *Spondylotreta? declivis*.

CONOTRETA DEPRESSA Cooper, new species

Plate 17, C, figures 29-57

Shell large for the genus, elliptical in outline, pedicle valve depressed, conical, with the posterior surface flattened; valves marked by fine concentric lines. Color shiny light brown often with alternating bands of light and darker color.

Pedicle valve depressed, circular in outline except for the posterior margin; lateral profile gently convex; anterior slope long and swollen; posterior slope short, flat; foramen small, apical; apical angle varying from about 90° to 110° . Anterior and lateral profiles showing strong, convex sides. Pseudointerarea wide, measuring somewhat more than half the width; intertrough not visible or showing a slight wave of the posterior margin or a faint longitudinal color band.

Brachial valve wider than long, fairly strongly convex in lateral profile, with the greatest convexity in the umbonal region; beak marginal, small and incurved; anterior quarter flattened; posterolateral slopes gently concave. Anterior profile broadly convex with the median region flattened slightly and with moderately long and gentle lateral slopes.

Pedicle interior with a small callosity excavated anteriorly; pedicle chamber moderately deep and narrow; pallial trunks deeply impressed at the rear, the outside one the deepest and bifurcating near its point of origin; outside trunk also bifurcating near the anterior edge of the callosity. Muscle scars well developed and located on the inner curved surface just outside the flattened inner surface of the palintrope.

Brachial interior with a long median septum extending for about two-thirds the valve length; septum rising to a point about one-third the length from the posterior margin; posterior triangular depression short, small, inconspicuous; propareas attenuated. Two sets of muscles well developed, the larger ones located just anterior to and outside the propareas, the smaller set located on each side of the median septum opposite its highest point.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 5.4 | 6.5 | 2.6 |
| Paratype (brachial valve 116815c) | 4.9 | 5.9 | ca. 0.5 |

Types.—Holotype: 116815e; figured paratypes: 116815a-d,f-m; unfigured paratypes: 116815n; figured specimen: 117967.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This is a large species approaching *C. magna* and *C. gigantea*, but the pedicle valve forms a much wider cone and the shell never attains the great thickness of the other two species.

CONOTRETA GIGANTEA Cooper, new species

Plate 16, E, figures 18-23; plate 17, D, figure 58; plate 17, E, figures 59, 60

Shell exceptionally large for the genus, circular in outline, forming a slightly curved and elongate cone. Base of cone slightly wider than long. Apical angle

40° to 60°. Beak curved posteriorly above the pseudointerarea which is narrow and one-half the width of the valve. Anterior side of cone strongly convex. Lateral surfaces strongly rounded. Surface marked by fine concentric lines.

Brachial valve slightly elliptical, wider than long; posterior margin narrow, nearly straight. Lateral and front margins strongly rounded. Lateral profile unequally convex with a moderately convex umbo and posterior third; convexity decreasing anteriorly to about two-thirds the length from the beak, where the valve is flattened. From here to the front margin it is gently concave. Beak marginal, protruding slightly posterior to the posterior margin. Median septum extending to middle.

Measurements in mm.—

| | Length | Width | Height |
|---|--------|-------|--------|
| Holotype (pedicle valve) | 5.9 | 6.8 | 6.3 |
| Paratype (brachial valve 109734d) | 8.0 | 7.8 | ? |

Types.—Holotype: 109734b; figured paratypes: 109734c,e, 117968a-c; unfigured paratypes: 109734a,d,f-m.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—See *Conotreta magna*.

CONOTRETA MAGNA Cooper, new species

Plate 16, D, figures 11-17

Shell large for the genus, resembling *C. gigantea* but dull black in color; pedicle valve forming an elongated cone; brachial valve nearly flat; surface marked by crowded concentric undulations and fine lines of growth.

Pedicle valve with the thickness or height of the cone about equal to the width; lateral profile conical with the posterior side flattened and slightly concave; anterior side moderately convex; anterior profile conical with very slightly convex sides; apical angle about 40°. Pseudointerarea narrow, measuring about 2½ mm. Intertrough shallow. Valve margin forming a circle. Interior unknown.

Brachial valve nearly circular, very slightly convex in profile with the umbonal region forming the most convex part; anterior half flattened; hinge line narrow; median ridge extending at least to the middle.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 7.0 | 7.4 | 7.8 |
| Paratype (brachial valve 109732a) | 5.7 | 6.2 | ? |

Types.—Holotype: 109733; figured paratypes: 109732a,b; unfigured paratype: 109732c.

Horizon and locality.—Whitesburg formation in Bulls Gap (T.V.A. 171-SE) Quadrangle, in Tennessee: 2 miles west of Bulls Gap Station, 1½ miles west of Bulls Gap, and 2¼ miles southeast of Whitesburg.

Discussion.—This species is most suggestive of *C. gigantea* but differs in its proportions and other details. *Conotreta magna* has a smaller apical angle than

the Alabama shell, and the pedicle valve is less curved. The pseudointerarea of the Tennessee species is much narrower than that of *C. gigantea*. The Alabama species has the appearance of being a lower and wider cone than the Tennessee shell.

CONOTRETA MULTISINUATA Cooper, new species

Plate 16, G, figures 28-40

Shell small, pedicle valve forming a low cone; brachial valve subcircular and gently convex. Apical angle 70° ; lateral angle 55° . Surface of both valves marked by very fine concentric lines of growth. Pseudointerarea triangular, equal in width to a little less than half the width of the valve. Lateral slopes from the pseudointerarea narrowly rounded. Anterior slope convex. Beak bent slightly posteriorly.

Brachial valve gently but unevenly convex in lateral profile and with the greatest convexity in the umbonal region. Lateral slopes flat and gentle; median sulcus deep, narrow, and extending from the umbo nearly to the front margin.

Interior of pedicle valve marked by as many as 14 pallial sinuses that are formed by the repeated branching of a main trunk situated on each side of the pedicle tube. Median septum long, extending nearly to the front margin, high and with its most elevated point at about the middle of the valve.

Measurements in mm.—Pedicle valve (109742g), length 2.3, width 2.8, posterior slope 1.6, anterior slope 2.8, width of pseudointerarea 1.2. Pedicle valve (109742f), length 2.7, width 3.2, posterior slope 2.4, anterior slope 3.1, width of pseudointerarea 1.3. Brachial valve (109742c), length 1.8, width 2.0. (109742a), length 2.2, width 2.0.

Types.—Holotype: 109746a; figured paratypes: 109739a, 109742f,h,p,r, 109746b-d; unfigured paratypes: 109736a-h, 109737a-c, 109738a,b, 109739b, 109740a-c, 109741a-k, 109742a-e,g,i-p,q,s-v.

Horizon and locality.—Botetourt formation in Virginia: $1\frac{1}{2}$ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle.

Chatham Hill formation in Virginia: Bland County, Grayson Farm, 4 miles southwest of Bland; 1 mile northwest of Lexington, Lexington (15') Quadrangle.

Whitesburg formation in Tennessee: 2 miles south of Albany and 8 miles northwest of Greenville, Mosheim (T.V.A. 181-NW) Quadrangle; $1\frac{1}{2}$ miles west of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: In a field northwest of U. S. Highway 11, $\frac{3}{4}$ mile southwest of Lacey Springs, Broadway (15') Quadrangle; southeast side of knob 1,000 feet east of Endless Caverns Entrance, Mount Jackson (15') Quadrangle.

Discussion.—This species is suggestive of *Spondylotreta? declivis* and *C. cuspidata*. It differs from the former in its ornamentation because it does not have the regular and fairly strong concentric lines characteristic of *Spondylotreta?*

declivis. It differs from *C. cuspidata* in having a less sharply pointed beak and a larger apical angle.

In the Athens limestone on the northwest side of U. S. (Lee) Highway 11, $\frac{3}{4}$ mile southwest of Lacey Springs, slabs can be obtained that contain many specimens of this species. These specimens are sufficiently mineralized to withstand etching in dilute hydrochloric acid. Many fine specimens preserving the details of the interior to perfection have been obtained.

CONOTRETA PLANA Cooper, new species

Plate 16, F, figures 24-27

Shell large for the genus, pedicle valve hemiconical in lateral profile; outline almost circular except for the flattened posterior margin. Angle formed by flattened area and anterior slope about 50° ; apical angle about 70° . Pseudointerarea broadly triangular, occupying more than half the width. Lateral slopes from pseudointerarea narrowly rounded. Pseudointerarea gently procline; beak bent a little anterior to the plane of the pseudointerarea.

Brachial valve unknown.

Measurements in mm.—Holotype, length 4.8, width 5.5, posterior slope 3.5, anterior slope 5.0, width of pseudointerarea 3.2.

Types.—Holotype: 109735b; unfigured paratype: 109735a.

Horizon and locality.—Effna formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species can be recognized by the broad, flat pseudointerarea which occupies more than half the posterior surface. It differs in this respect from all other species described herein.

CONOTRETA RUSTI Walcott

Plate 16, H, figure 41

Conotreta rusti WALCOTT, Proc. U. S. Nat. Mus., vol. 12, p. 365 (extract 1889), figs. 1-4, 1890.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 104, pl. 4, K, figs. 16-21, 1892.

Types.—Lectotype: 18443a (fig. 1); paratype: 18443b.

Horizon and locality.—Trenton limestone in New York: Trenton Falls. Salona formation in Pennsylvania: At Salona.

CONOTRETA TRIANGULATA Cooper, new species

Plate 28, A, figures 1-4

Shell large for the genus, outline an irregular cone, nearly planoconvex; surface exfoliated. Pedicle valve with elongate-oval cross section, short posterior slope, and a long but steep anterior slope; lateral slopes steep; false interarea narrow. Brachial valve elongate oval with posterior margin somewhat more narrowly rounded than the anterior margin; nearly plane in profile.

Measurements in mm.—Holotype, length 9.9, brachial length 9.2, midwidth 8.8, thickness 5.4.

Type.—Holotype: 117973.

Horizon and locality.—Effna formation in Virginia: On the north side of Virginia Highway 114, 7 miles northeast of Lusters Gate, near Blacksburg, Va.

Discussion.—This species suggests *C. magna*, *depressa*, and *gigantea* because of its large size. It differs from the first and last in its much less elevated conical form. It is more like *C. depressa* in its low conical profile but differs in having a narrower false interarea and a nearly plane brachial valve.

SPONDYLOTRETA Cooper, new genus

(Greek *spondylium*, vertebra; *tretos*, opening)

Shell small, conical in profile, the cone flattened on the posterior side by a prominent and broad pseudointerarea. Surface marked by regular, strong concentric elevated lines.

Brachial valve with slightly postapical foramen; pedicle tube entering valve between a high median septum and the posterior inner surface; pedicle tube continued along wall as a forked ridge dying out about half the distance to the margin.

Brachial valve gently concave in both profiles; moderately sulcate; hinge region with a median triangular depression and thin, short plate anterior to it and overhanging the space between the hinge margin and the median septum. Median septum long, originating just anterior to the hinge margin and extending nearly to the front margin, triangular in profile with the apex of the triangle just posterior to the middle. Two large muscle marks occupy the posterolateral areas.

Genotype.—*Spondylotreta concentrica* Cooper, new species.

Discussion.—This genus is quite unlike any of the others herein described in its septate pedicle valve. The strong median septum evidently serves the same purpose as the anteroapical callosity of *Conotreta*.

Some uncertainty exists as to the assignment of this concave brachial valve to this genus. It is the only specimen like it recovered from this locality, and it is marked externally like the pedicle valves to which it is assigned.

On the basis of its regularly concentric ornamentation Willard's *Conotreta declivis* is assigned with doubt to this genus. The interior of Willard's species is not known, and only two specimens occur in the National Collection.

SPONDYLOTRETA CONCENTRICA Cooper, new species

Plate 18, A, figures 1-7

Shell small, conical in profile with the posterior side flattened; surface marked by fairly strong, even concentric, elevated lines.

Pedicle valve a misshapen cone in lateral profile with the posterior side flattened by the pseudointerarea; anterior side gently convex; apex bluntly pointed; apical angle about 85°. Anterior profile with sides gently convex. Beak very slightly incurved and perforated by a small circular foramen. Pseudointerarea broad and flat; intertrough not clearly defined. Interior with a long pedicle tube entering the valve just posterior to an erect and long median septum on the

anterior slope of the interior; on the posterior the end of the tube is extended along the inner surface of the valve as a forked ridge extending for more than half the length. The forked ridge dies out gradually and expands slightly toward the margin.

Brachial valve nearly circular; gently concave in lateral profile; anterior profile concave; valve deepest in the median region; posterolateral extremities deflected slightly in a brachial direction; beak small; umbo narrowly swollen; valve gently sulcate anterior to umbo. Interior with a triangular depression in the median part of the hinge region and with a small, thin plate built anteriorly from this depression; propareas small; median septum originating just anterior to the triangular depression and extending nearly to the front margin; median septum broadly triangular in profile with its apex located just posterior to the middle.

Measurements in mm.—

| | Length | Width | Thickness | Height of septum |
|-------------------------------------|--------|-------|-----------|------------------------|
| Holotype (pedicle valve) | 2.0+ | 2.0+ | 2.0 | ? |
| Paratype (brachial valve 116826c) . | 2.7 | 3.3 | ? | 0.7 |

Types.—Holotype: 116826a; figured paratypes: 116826b,c.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its large size and broad apical angle. It therefore differs markedly from *S. ? declivis* (Willard).

SPONDYLOTRETA ? DECLIVIS (Willard)

Plate 16, C, figures 8-10

Conotreta declivis WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 258, 1928.

Small, irregularly conical in outline and profile. Posterior slope gently concave but anterior slope gently convex. Pseudointerarea wide, marked medially by a fairly wide but shallow intertrough. Apical angle 55°; lateral angle 50°. Posterior margin gently concave. Surface marked by strong, fairly regular concentric lines.

Measurements in mm.—Pedicle valve, posterior slope 2.3, anterior slope 3.0, width 2.7.

Types.—Holotype: M.C.Z. 8593; figured hypotype: 109727a; unfigured hypotypes: 109727b,c.

Horizon and locality.—Effna formation in Virginia: McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Discussion.—This species is externally very close to *C. cuspidata* but differs in having a slightly smaller apical angle and much stronger concentric ornamentation. It is a much smaller species than *S. concentrica* and has a much smaller apical angle. It is referred to *Spondylotretra* on the basis of the even, concentric ornamentation which is quite unlike that of *Conotreta*, although its interior is unknown.

TORYNELASMA Cooper, new genus

(Greek *toryne*, spoon; *elasma*, plate)

Small, acutely conical in profile; surface marked by fine concentric lines.

Pedicle valve with acute apex and minute apical foramen; pseudointerarea not clearly marked; intertrough narrow, shallow, indistinct.

Brachial valve convex in lateral profile; median septum originating a short distance anterior to the posterior margin and surmounted by a long, shallow, spoonlike plate. Median hinge region with a short, shelflike plate overhanging space between posterior end of spoon and posterior margin.

Genotype.—*Torynelasma toryniferum* Cooper, new species.

Discussion.—In its exterior features, particularly its profile, this genus is like several others but is characterized by the extremely sharp beak. The spoon-shaped plate on the median septum is, as far as known, unique.

TORYNELASMA MINOR Cooper, new species

Plate 18, I, figures 57-64

Shell minute, conical, pale yellow to brown in color, and marked by fine concentric lines.

Pedicle valve forming a fairly symmetrical cone with strongly oblique opening; beak acute; apical angle between 30° and 40° ; anterior margin gently sinuate.

Brachial valve nearly circular in outline; lateral profile gently convex; anterior sulcate; posterior moderately swollen. Interior with a short, erect, spoon-shaped plate set on a high median septum, both structures originating near the posterior margin; septum highest near the middle of the valve and not protruding anterior to the anterior end of the spoon-shaped plate but extending as a sharp point anterior to the anterior end of the spoon. Spoon-shaped plate short and flat. A small circular muscle platform appears on each side of the thin posterior end of the median septum.

Measurements in mm.—

| | Length | Width | Thickness | Height of spoon plate |
|-------------------------------------|--------|-------|-----------|--------------------------------|
| Holotype (brachial valve) | 0.6 | 0.70 | ? | 0.4 |
| Paratype (pedicle valve 116823d) .. | 0.64 | 0.75 | 1.06 | ? |

Types.—Holotype: 116823a; figured paratypes: 116823b-d; unfigured paratypes: 116823e-h.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species differs from the preceding one in its smaller size and the character of the spoon-shaped plate in the brachial valve. In this species the plate is flatter, shorter, and more elevated than in *T. toryniferum*. Furthermore, the septum is quite different in this species in having its own pointed crest anterior to the spoon-shaped plate, the anterior end of which is unsupported.

TORYNELASMA TORYNIFERUM Cooper, new species

Plate 9, C, figures 9, 10; plate 18, E, figures 28-36; plate 28, E, figures 13-16

Shell small, acutely and fairly symmetrically conical in profile; color shiny straw-yellow; surface marked by fine, concentric lines.

Pedicle valve fairly symmetrically conical in both profiles; margins almost roundly elliptical, strongly oblique to the shell axis; posterior side convex in cross section and thus without a conspicuous pseudointerarea; intertrough inconspicuous; apical angle 35 to 40°.

Brachial valve roundly elliptical in outline; fairly strongly convex in lateral profile; broadly convex in anterior profile; beak small, slightly protruberant. Brachial interior with shelflike area, short but wide, extending anteriorly from the hinge over the interior; spoon-shaped plate narrow posteriorly but widening anteriorly to reach its widest point near the anterior end; median septum crested anteriorly and reaching its highest point at its anterior extremity; median septum protruding slightly anterior to the anterior end of the spoonlike plate; spoon-shaped plate characterized by a deep median area with a rim on each side set off by a longitudinal suture line.

Measurements in mm.—

| | Length | Width | Thickness | Height of septum |
|-------------------------------------|--------|-------|-----------|------------------------|
| Holotype (brachial valve) | 1.1 | 1.6 | 0.4 | 0.75 |
| Paratype (pedicle valve 116824a) .. | 1.3 | 1.8 | 2.5 | ? |

Types.—Holotype: 116825c; figured paratypes: 116824a-c, 116825d-f; unfigured paratypes: 116824d, 116825a,b,g,h.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its fairly large size, the acutely pointed pedicle valve, and the deep, spoon-shaped plate supported for its entire length by the median septum. Besides its size, it differs in the latter respect from *T. minor* in which the anterior end of the spoon-shaped plate is free and the anterior end of the median septum forms a free point.

RHYSOTRETA Cooper, new genus

(Greek *rhysos*, wrinkled; *tretos*, opening)

Shells small, thick, conical in outline; surface of both valves marked by regular, closely spaced, concentric elevated rings.

Pedicle valve conical in profile; posterior side flattened to form a pseudointerarea; intertrough usually narrow, shallow. Foramen large, tear-shaped, with the apex of the tear at the valve apex; foramen located just posterior to the apex.

Brachial valve nearly flat in both profiles but deeply concave anterior to the umbo and in the median part of the valve; anterior rim often convex.

Pedicle interior without any trace of muscle marks or septa. Brachial interior with a strong median septum arising a short distance anterior to the posterior margin and extending to the front margin. Septum highest at its anterior end.

Posterior margin straight and characterized by a pseudointerarea of considerable length in old shells; pseudointerarea often growing as a shelf over posterior end of median septum. Two large muscle scars occupy the posterolateral areas on each side of the median septum.

Genotype.—*Rhysotreta corrugata* Cooper, new species.

Discussion.—This pretty little genus is characterized by its concave brachial valve, the strongly corrugated exterior, and the fairly large tear-shaped pedicle opening. Unfortunately, none of the numerous specimens obtained by solution of limestone by acetic acid shows any details of the muscle system of the pedicle valve.

The inside of the brachial valve is characterized by a strong median septum that rises to its highest point at the anterior end of the valve. This septum originates near the middle of the valve in very young specimens. The small brachial valve is also deeply concave, but as it grows, the anterior thickens and levels off to form a flattened anterior rim. This rim in old shells may grow toward the pedicle valve and produce a strongly convex rim.

RHYSOTRETA CORRUGATA Cooper, new species

Plate 18, F, figures 37-50

Shell small, thick, forming a cone with flattened posterior; surface marked by strong, rounded concentric rings.

Pedicle valve with anterior margin gently convex; posterior margin flat to gently convex; lateral slopes strongly rounded; anterior profile with very gently convex sides; apical angle about 30° , pseudointerarea broad, flat but marked by concentric corrugations, intertrough variable, broad to narrow but always shallow; beak blunt; foramen large, located on the posterior side of the beak.

Brachial valve with nearly straight hinge line; beak small, protruding beyond the posterior margin; lateral profile flat to slightly concave; anterior profile gently concave; median region deeply concave.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 1.3 | 1.6 | 1.0 |
| Paratype (brachial valve 116817d) | 1.4 | 1.9 | 0.3 |

Types.—Holotype: 116817a; figured paratypes: 116817b-g.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species is now known with which this one can be compared.

SCAPHELASMA Cooper, new genus

(Greek *scaphos*, hollow; *elasma*, plate)

Shell small, elliptical in outline, conical in profile; surface marked by fine concentric lines and in the anterior half by imbricating lamellae.

Pedicle valve symmetrically conical in anterior profile but forming a cone

flattened on the posterior side in lateral profile; pseudointerarea broad; intertrough fairly wide and deep, extending to the beak; foramen small, located on the posterior side of the beak at the place of origin of the intertrough, and having a narrow, shallow groove anterior to it.

Brachial valve roundly elliptical in outline; flat to moderately concave in lateral profile.

Pedicle interior with strong ridge on palintrope representing internal track of intertrough; foramen surrounded by a thickened and elevated rim; brachial interior with prominent median septum originating at the middle of the valve in young specimens but never growing much farther posteriorly in the adult; median septum highest near the front margin, notothyrial region closed by a short but prominent shelf.

Genotype.—*Scaphelasma septatum* Cooper, new species.

Discussion.—This genus is characterized by its fairly symmetrical conical form, deep intertrough with foramen set in its anterior end and the median septum occupying the anterior half of the valve. In the latter respect it resembles *Rhyso-treta*, but the septum never grows to the rear of the shell as in the latter genus. It also resembles *Rhyso-treta* in having the small shelf that grows anterior to the beak of the brachial valve and overhangs the cavity between the median septum and posterior margin. *Scaphelasma* is quite unlike *Rhyso-treta* in the size of the foramen and the ornamentation.

SCAPHELASMA SEPTATUM Cooper, new species

Plate 18, J, figures 65-73

Shell small, generally straw-yellow in color, transversely elliptical in outline and conical in profile. Surface in the umbonal region marked by fine concentric lines; but in the marginal region by strong undulations or imbrications.

Pedicle valve forming a symmetrical cone with convex sides in anterior profile; lateral profile conical with the beak slightly posterior to the center, the anterior slope being flat to slightly convex and longer than the posterior slope; posterior slope steep and convex; intertrough wide, extending to foramen. Foramen located somewhat posterior to the beak at the end of a narrow and shallow trough. Interior as described for the genus.

Brachial valve with posterior half marked by fine growth lines only but anterior half imbricate with strong plaits. Lateral profile convex in the umbonal region, becoming concave anterior to the umbo but convex again in the plaited portion; anterior profile nearly flat except for the median region which is gently concave; beak narrowly swollen and protruding posterior to the posterior margin; swollen umbonal areas extend anterolaterally to the plaited area; sulcus originating just anterior to umbo and extending to anterior margin.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 1.1 | 1.4 | 0.6 |
| Paratype (brachial valve 116819h) | 1.1 | 1.4 | 0.3 |

Types.—Holotype: 116819a; figured paratypes: 116819b-h, unfigured paratype: 116820.

Horizon and locality.—The Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species of this genus is available for comparison.

EPHIPPELASMA Cooper, new genus

(Greek *ehippium*, saddle; *elasma*, plate)

Shell minute, elongate conical in profile, surface marked by fine concentric lines.

Pedicle valve elongate conical with apex curved in a posterior direction; foramen minute, apical; pseudointerarea wide; intertrough indistinct; anterior margin with slight sinuation. Interior not showing muscle scars.

Brachial valve gently concave, sulcate; interior with a large complicated saddle-shaped plate originating about one-third the length anterior to the posterior margin; saddle-shaped plate bearing several prongs along its anterior borders, generally 5 in number. Hinge region with a small shallow triangular pit and narrow propareas.

Genotype.—*Ehippelasma minutum* Cooper, new species.

Discussion.—No known genus is comparable to *Ehippelasma*. The only genus known with a structure of the brachial valve similar to that of *Ehippelasma* is *Prototreta* Bell, but in that Middle Cambrian genus the median plate is constructed entirely differently.

EPHIPPELASMA MINUTUM Cooper, new species

Plate 17, A, figures 1-14

Shell minute, elongate conical in outline with the posterior side flattened; surface marked by crowded, fine, concentric lines.

Pedicle valve forming a misshapen cone in lateral profile with the posterior side gently concave and the anterior side broadly convex; in anterior profile the sides of the cone equal and slightly convex; anterior margin with a slight emargination; apical angle about 40°. Pseudointerarea broad with a faint narrow intertrough; beak incurved, foramen at the apex, minute.

Brachial valve with a nearly straight and wide hinge; roundly elliptical in outline; later margins somewhat narrowly rounded; anterior margin broadly rounded; lateral profile nearly plane; anterior profile gently concave medially; median region of valve more or less deeply concave; umbonal region somewhat narrowly swollen; beak small, protruding slightly posterior to the posterior margin. Sulcus broad and shallow, extending from anterior side of umbo to front margin. Interior as described for the genus.

Measurements in mm.—

| | Length | Width | Thickness | Height of dorsal plate |
|-------------------------------------|--------|-------|-----------|---------------------------------|
| Paratype (pedicle valve 116821d) .. | 0.6 | 0.75 | 0.9 | ? |
| “ (brachial valve 116821f) . | 0.6 | 0.9 | ? | 0.6 |

Types.—Holotype: 116821a; figured paratypes: 116821b-i; unfigured paratypes: 116821j-l.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its minute size, sulcate brachial valve, and upturned pedicle beak. No other species of the genus is known, and no other genus has a species quite like it.

UNDIFERINA Cooper, new genus

(Latin *unda*, wave; *fero*, bear)

Shell small, subrectangular in outline; hinge straight; sides and anterior margin irregular; anterior margin often emarginate; surface marked by fine, concentric lines of growth; surface often thrown into irregular wrinkles and knobs. Beaks small protuberant.

Brachial interior with median triangular depressed area at the hinge bounded by short palintrope with narrow, triangular pseudointerareas; triangular depression occupied by a short triangular plate; small toothlike projections at anterior edge of pseudointerarea; median ridge extending from a point just anterior to triangular plate nearly to front margin; median septum highest at anterior end with its free edge often modified into a narrow tube; muscle marks not clear, but a large muscle seems to have been inserted just under the toothlike projections of the palintrope.

Genotype.—*Undiferina rugosa* Cooper, new species.

Discussion.—This peculiar little brachiopod presents many unusual features. Its exterior and outline are exceptional; the hinge region is not like any other inarticulate; and the median septum is often bizarre in its development.

The outline and exterior ornamentation suggest a brachiopod that may have been attached. The irregular character of the exterior surface with its wrinkles and knobs is suggestive of *Crania*, which often takes the surface ornamentation of its host. The irregularity of the margins is similarly suggestive.

Not in accord with the above views is the straight hinge and the apparent toothlike processes on each side of the triangular area. These are suggestive of some sort of articular apparatus, but the valve seems to be a brachial valve rather than a pedicle valve. The strong median septum and the triangular median depression with its thin plate are features of the brachial valve of several genera of inarticulate brachiopods described herein.

Full knowledge of this peculiar shell cannot be had until the pedicle valve is known. If this valve should prove to be a cementing one, it may never be found with the methods that are at present necessary in collecting this type of material. If it is not a cementing form, it should ultimately be found as more etching is done.

This genus is placed tentatively in the Acrotretinae because of the strong development of the median septum, a feature of all known Acrotretinae.

UNDIFERINA RUGOSA Cooper

Plate 18, B, figures 8-21

Shell small, subrectangular in outline with a straight hinge but irregular sides and anterior margin; sides generally somewhat narrowly rounded; anterior margin usually broadly rounded, often irregular, sinuate or emarginate on one side. Surface marked by fine concentric lines superimposed over irregular shell undulations and knobs.

Interior as described for the genus.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 1.8 | 2.1 | 0.5 |
| Paratype (116832a) | 2.0 | 2.6 | 0.5 |
| “ (116832c) | 1.9 | 2.6 | 0.6 |

Types.—Holotype: 116832b; figured paratypes: 116832a,c-f; unfigured paratypes: 116832g,h.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 miles southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species is known to which this one may be compared.

Superfamily SIPHONOTRETACEA Schuchert and Walcott, 1908

Family SIPHONOTRETIDAE Kutorga, 1848

Usually oval shells with an oval or subcircular pedicle opening at the apex or passing by resorption through the protogulum and umbo.

Genus **SIPHONOTRETA** Verneuil, 1845

Siphonotreta VERNEUIL, Geol. Russia, vol. 2, p. 286, 1845.

SIPHONOTRETA AMERICANA Cooper, new species

Plate 14, A, figures 1-11

Shell small for the genus, oval in outline, ornamentation with posterior third marked by fine, distant concentric lines and fine radial lines which develop a spine at their intersection; anterior two-thirds finely lamellose, each lamella bearing one or more rows of fine spines, measuring slightly over $1\frac{1}{2}$ mm. at the front margin.

Pedicle valve width equal to about two-thirds the length. Greatest width just anterior to the middle; apical angle about 100° . Lateral margins broadly rounded; anterior margin somewhat narrowly rounded. Lateral profile moderately strongly convex with the maximum convexity located in the umbonal region; anterior profile broadly but fairly strongly convex; posterolateral slopes rounded and steep. Foramen, small, oval, about 1 mm. long and located just anterior to the apex.

Brachial valve slightly longer than wide with strongly rounded margins and gently convex profiles. Umbonal region sulcate, sulcus gradually widening an-

teriorly but barely perceptible or obsolete in the front half of the valve. Beak smooth. Umbonal region marked by obscure concentric lines and indefinite radii. Small spines numerous on all parts of the shell but confined to lamellae on the front two-thirds.

Measurements in mm.—

| | Length | Width | Thickness |
|---------------------------------------|--------|-------|-----------|
| Holotype (pedicle valve) | 8.3 | 6.8 | 2.0 |
| Paratype (pedicle valve 109635) | 8.6 | 8.0 | 1.8 |
| " (brachial valve 109636c) | 7.5 | 7.7 | 1.0 |
| " (" " 109636b) | 9.1 | 8.4 | 1.3 |

Types.—Holotype: 109636f; figured paratypes: 109635, 109636b,d,e,g; unfigured paratypes: 109636a,c,h-m.

Horizon and locality.—Arlene formation in Tennessee: $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—The external expression of this species is like that of *Schizambon*, but the two genera can be readily distinguished by the fact that the foramen of *Siphonotreta* does not produce a long growth groove but is confined to the umbo. No other species of *Siphonotreta* is known in these rocks to which *S. americana* can be compared, but *S. tertia* of the Canadian (Sarbach) of Alberta is similar. The latter species differs from the one described herein by the finely papillose exterior and the absence of strong concentric lines.

Genus SCHIZAMBON Walcott, 1884

Schizambon WALCOTT, U. S. Geol. Surv. Mon. 8, p. 69, 1884.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 113, 1893.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 60, 1938.

This is generally a rare or unusual genus in the rocks above the Cambrian, but in the Southern Appalachians and at the Rock Crossing of Hickory Creek in Criner Hills, Okla., it is fairly common. Although the collection studied for this monograph is probably larger than any other of this genus ever brought together, it is nevertheless quite inadequate for a detailed study of the interior characters of this peculiar brachiopod. Although a question mark has not been placed after the generic name of any of the species referred to *Schizambon* in this book, it is doubtful if any of them are congeneric with *S. typica* of the Pogonip (Goodwin) formation. All these species conform to the present generic description, but that is obviously inadequate.

Several differences between the Cambrian and Lower Ordovician *Schizambons* on the one hand and the Post-Canadian ones on the other are easily observable. All the Marmor-Trenton species observed by the writer are 2 or 3 times larger than the earlier ones, and the ornamentation is more elaborate. Furthermore, as pointed out by Hall and Clarke, no long pedicle tube occurs on the inside of the genotype as it does in *S. canadensis* and in some of the species described herein. The beginnings of such a tube is shown in *S. borealis* Ulrich and Cooper.

The few specimens of Post-Canadian *Schizambon* in the National Museum collection that show the internal surface or are impressions of that surface fail

to show any details of the musculature or pallial impressions. One brachial valve, plate 15, C, figure 7, gives indications of a median ridge, but the structure is badly crushed and it is impossible to make sure of its details.

A few specimens show the posterior margin fairly well. This margin on the pedicle valve swells slightly in an anterobrachial direction and fits into a slight reentrant anterior to the beak on the margin of the brachial valve.

Schizambon, even though locally fairly common, ranges too high vertically and is generally too rare to be of great value in stratigraphy. It occurs in all types of matrix from the calcarenite marbles to the black limestones and shales of the Liberty Hall facies.

SCHIZAMBON CUNEATUM Willard

Plate 15, E, figures 20-22

Schizambon cuneatus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 257, pl. 1, fig. 4, 1928.

Shell large for the genus, suboval in outline, and with the valves unequal in depth and outline. Lateral margins gently rounded; anterior margin narrowly rounded. Greatest width at about the anterior third.

Pedicle valve slightly convex in lateral profile, broadly convex in anterior profile. Track of foramen widening gradually, in length equal to about one-third the valve length. Median region from foramen nearly to front margin slightly swollen. Lateral slopes short and moderately steep. Area surrounding pedicle groove marked by closely spaced, elevated concentric lines. Anterior two-thirds marked by pairs of concentric bands. Spines slender, about 2 mm. or less in length.

Brachial valve nearly circular in outline, gently convex in both profiles. Sulcus originating at beak, shallow, widening gradually anteriorly to the front margin. Sulcus defined by 2 distinct but narrow costae. Flanks gently convex. Umbonal region marked by small spines arranged alternately, the space between each spine marked by a fine elevated line, the radial and concentric elements producing a very fine cancellation. Anterior to the umbonal region valve marked by paired concentric bands.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (pedicle valve) | 14.2 | 12.8 | ? |
| Hypotype (brachial valve 109668) | 12.4 | 13.5 | ? |

Type.—Holotype: M.C.Z. 8588; hypotype: U.S.N.M. 109668.

Horizon and locality.—Effna formation in Virginia: McNutt's Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: Hays Creek, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Discussion.—This species is most like *S. macrothyris* but differs in having a smaller and more symmetrical pedicle groove, not having radial elements in the

ornamentation about the pedicle groove and in having the anterior two-thirds marked by concentric lamellae in pairs.

SCHIZAMBON DUPLICIMURATUM Hudson

Plate 13, D, figure 6; plate 15, B, figures 5, 6

Schizambon duplicimuratus HUDSON, Rep. New York State Paleont. for 1903, p. 284, pl. 5, figs. 6, 7, 1904.—RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 228, pl. 34, figs. 23-24, 1911.—TWHENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 45, pl. 7, fig. 16, 1938.

Figured specimens.—117954; A.M.N.H. (no number).

Horizon and locality.—Crown Point formation in New York: At Crown Point, Valcour Island, and Chazy.

Mingan formation: Mingan Islands, St. Lawrence River, Quebec.

Discussion.—This species suggests *S. cuneatum* in the presence of paired concentric lines, but it is smaller, rounder, and the median sulcus of the brachial valve does not reach the margin.

A pedicle interior in the collection is referred to this species, but the structures are not well preserved. The foramen is located about 2 mm. anterior to the posterior margin and enters the valve in the median part of a considerable callus development occupying the posterior half. Anterior to this callus and near the lateral margins occurs a pallial trunk. Muscle marks are not clearly visible. The specimen comes from the St. Martin formation, $\frac{1}{2}$ mile north of Cap St. Martin, Quebec, Canada.

SCHIZAMBON HIRSUTUM Cooper, new species

Plate 15, D, figures 18, 19

The material on which this species is based consists of a fragmentary pedicle valve and a nearly complete brachial valve. The specimens are large for the genus. The remains of the pedicle valve indicate an ovate shell with a long and large foramen and pedicle growth track. The brachial valve is nearly circular in outline as usual for the genus. The median sulcus is narrow but deep in the umbonal region, widening anteriorly and becoming lost in the general convexity of the valve near the middle. The surface of both valves is marked by many moderately closely spaced lamellae that are ornamented by numerous crowded and very small spines, measuring about 2 mm. in length. The holotype (brachial valve) is 12 mm. long, but probably at least 3 mm. are missing from the anterior; width 11.8 mm.

Types.—Holotype: 109670a; paratype: 109670b.

Horizon and locality.—Murat formation, Whistle Creek, Va.: Along road and ridge, 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species is suggestive of *S. cuneatum* but differs in having concentric rows of fine spines and in not showing the paired concentric lines characteristic of that species.

SCHIZAMBON IRREGULARE Cooper, new species

Plate 14, C, figures 20, 21

This species is represented by a single brachial valve that may be distinguished from all other members of this genus by the irregularity of its surface markings. It is subcircular in outline, moderately convex in profile with the strongest curvature at the middle. The lateral profile is moderately convex with maximum convexity at the middle; anterior profile gently and broadly convex. The umbo is smooth; the umbonal region is traversed by a shallow but wide sulcus which disappears at about the posterior third. The posterior half of the valve is without imbrications but is marked by discontinuous short and wavy lines and scattered spines. The spines are about 1.5 mm. in length.

Measurements in mm.—Holotype, length 12.0, width 12.0.

Type.—Holotype: 109669.

Horizon and locality.—Arline formation in Tennessee: On Sevierville Pike, 3 miles southeast of Knoxville, Knoxville (T.V.A. 147-NW) Quadrangle.

SCHIZAMBON LINEATUM Cooper, new species

Plate 14, D, figures 22, 23

A single brachial valve has unusual characters that separate it from all other known species of the genus. The convexity in lateral profile is moderately strong and the outline is oval, the shell narrowing posteriorly. In anterior profile the valve is broadly convex. The median portion is somewhat swollen and the descent to the margins is short but moderately steep. The ornamentation consists of strong lamellae as is usual for the genus, but the lamellae are ornamented by elevated, wavy concentric lines, often as many as 3 or 4 lines to a lamella. Large spines occur scattered over the surface, but fine nodes on the concentric lines indicate that rows of fine spines covered the entire shell. At the front margin the fine spines have a length of 2 mm.

Measurements in mm.—Holotype, length 16.0, width 14.5, thickness 3.5.

Type.—Holotype: 109671.

Horizon and locality.—Wardell formation in Virginia: 1 mile northeast of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

SCHIZAMBON MACROTHYRIS Cooper, new species

Plate 15, A, figures 1-4; plate 22, L, figures 22-24

Shell large for the genus, elongate, oval in outline; posterior pointed, lateral margins gently rounded, anterior margin broadly rounded. Greatest width at about anterior third.

Pedicle valve gently convex in the umbonal region, very faintly convex in the anterior two-thirds. Track of foramen equal in length to one-third the length of the valve, widening rapidly. Foramen elliptical. Region about the pedicle track ornamented by nearly equally distant, elevated concentric lines which are crossed by fine discontinuous radial lines occupying the entire umbonal region.

Anterior two-thirds ornamented by lamellae bearing spines of 2 sizes, many small spines and a few large ones; last 3 lamellae at the front crowded together.

Brachial valve strongly convex in anterior profile and moderately strongly convex in lateral profile. Sulcus deep but narrow in the umbonal region, widening anteriorly for about one-third the length and then disappearing. Umbonal region for about one-third its length marked by distant elevated concentric threads and moderately crowded large spines. Lamellae of anterior two-thirds moderately distant, provided mainly with large spines. Small spines few.

Measurements in mm.—Holotype, length 15.8, width 13.2, thickness 8.5.

Types.—Holotype: 98204a; figured paratypes: 116928a-c.

Horizon and locality.—Wardell formation in Virginia: Lloyd Carter's barn, $\frac{3}{4}$ mile by road northeast of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; south of road, $\frac{1}{2}$ mile east-northeast of Belfast Mill, Saltville (T.V.A. 212-NE) Quadrangle; $\frac{1}{2}$ mile northwest of Rockdell, Elk Garden (T.V.A. 212-NW) Quadrangle; $1\frac{1}{2}$ miles west of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Benbolt formation in Virginia: Behind Brick Church west of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species in size and outline is very like *S. cuneatum*, but it differs in having an unusually large and wide foramen, the median sulcus of the brachial valve is faint and scarcely reaches the middle, while the ornamentation consists of strong, thick lamellae.

SCHIZAMBON PERSPINOSUM Cooper, new species

Plate 15, C, figures 7-17

Shell of moderate size for the genus; oval in outline with the length slightly greater than the width. Lateral and front margins strongly rounded; apical angle about 120° .

Pedicle valve with posterior two-thirds slightly swollen and gently convex, anterior third flattened or depressed to produce a slight inward bend. Beak blunt, pedicle track extending for about one-third valve length. Foramen large and oval. The region about the beak is ornamented by evenly spaced, elevated concentric lines. Anterior to the beak the lamellose structure of the shell becomes pronounced, and the concentric lines, though still present, become less and less numerous anteriorly.

Brachial valve elongate ovate in outline with moderately rounded lateral margins and narrowly rounded anterior margin. Lateral profile gently convex with a slight geniculation toward the pedicle valve in the anterior third to half. Anterior profile moderately but unevenly convex, the lateral portions incurving narrowly. Posterior half ornamented by elevated discontinuous and wavy concentric lines which are interrupted by scattered large spines. In the anterior half the valve becomes lamellose, the concentric lines become fewer and disappear. Each lamella bears on its edge long, hollow spines up to 6 mm. in length.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 11.0 | 9.6 | 1.5 |
| Paratype (brachial valve 109681b) | 14.2 | 14.1+ | ? |
| " (" " 109681d) | 12.5 | 10.7 | ? |

Types.—Holotype: 109681c; figured paratypes: 71891a, 109678, 109680, 109681a,d; unfigured paratypes: 71891b-d, 109679a,b, 109681b,e,f; figured specimen: 109688.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectia gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County; (zone 5), Spring Creek, N½ sec. 17, T. 2 S., R. 1 W., Murray County.

Bromide formation (Mountain Lake member) in Oklahoma: Brownish granular beds, Rock Crossing, as above.

Discussion.—This species is fairly common in the Criner Hills and is characterized by moderate size and very long spines. In these respects it differs from *S. canadensis* (Ami) which is a large species, and also from *S. dodgei* in which the spines are reported as only 2 mm. in length. The pedicle umbo is faintly radiate as in *S. subradiatum*, but the latter is a much smaller shell with a more convex pedicle valve and different anterior ornamentation.

SCHIZAMBON SUBRADIATUM Cooper, new species

Plate 14, B, figures 12-19

Shell of about average size for the genus, a little wider than long. Apical angle about 110°. Lateral margins of adults strongly rounded; anterior margin more gently rounded.

Pedicle valve oval; faintly convex in the posterior half but becoming flat and very gently concave in the anterior portion. Length of pedicle track about one-third the length of the valve. Beak pointed; posterior slope steep. Region about the pedicle track and foramen marked by elevated, closely spaced, somewhat wavy concentric lines. A few obscure radial lines extending from the beak to a point opposite or a little anterior to the foramen. Spine-bearing lamellae closely spaced.

Brachial valve subcircular in outline with both profiles moderately convex. Sulcus narrow and deep at the point of its origin at the beak, widening very gradually to the middle of the valve and becoming merged into the flattened anterior third. Posterior third with distant and subdued concentric lines and a few spine bases. Beak and umbo smooth. Lamellae distant; spines numerous, about 1.5 mm. in length.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype (pedicle valve) | 9.4 | 8.6 | ? |
| Paratype (pedicle valve 109685a) | 8.8 | 7.7 | 1.8 |
| " (brachial valve 109686a) | 7.2 | 7.9 | ? |

Types.—Holotype: 109686c; figured paratypes: 109686d,e,g; unfigured paratypes: 109685a,b, 109686a,b,f,h-l.

Horizon and locality.—Arline formation in Tennessee: About $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is characterized by the faint radii on the umbo surrounding the pedicle groove and by the small size of the spines. It is suggestive of a small *S. cuneatum* but is less oval than that species and is usually much smaller and with shorter spines.

SCHIZAMBON sp. 1

Plate 21, A, figures 1, 2

The specimen illustrated is probably the young of one of the larger forms of *Schizambon* from the Effna formation, but it is not possible to make an accurate specific determination. The specimen shows some details of the interior, especially the elevated rim around the elongate track of the pedicle opening.

Figured specimen.—123306.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

SCHIZAMBON sp. 2

Plate 21, B, figures 3-6; plate 22, J, figure 17

Abundant in the washings from the acetic acid digestion of the Pratt Ferry limestone from Pratt Ferry, Blocton Quadrangle, Ala., are numerous specimens of a small *Schizambon*. The pedicle valves generally occur as only the posterior parts, and usually the foramen does not show any marked growth toward the anterior. For this reason and because of their small size the specimens are regarded as youthful. Young characters are also to be seen in the ornamentation of the pedicle valve which has strong radii extending from the beak to the anterior margin. The interior of the pedicle valve shows few characters. The foramen enters the interior at the posterior of a somewhat thickened umbonal region. The sides of the foramen are often thickened slightly, but no trace of muscle or pallial marks is visible.

The brachial valve has strong concentric lamellae and a more or less deep sulcus extending from the beak to the anterior margin. On the inside the path of the sulcus is shown as a low ridge on the interior. A large subcrescentic muscle scar appears on a side of the median ridge near the middle of the valve.

Figured specimens.—109687, 116829a-d.

Superfamily DISCINACEA Waagen, 1885

Family TREMATIDAE Schuchert, 1893

More or less circular shells in which the margin of the pedicle valve is notched for the extrusion of the pedicle; brachial valve subconical.

Genus TREMATIS Sharpe, 1847

Trematis SHARPE, Quart. Journ. Geol. Soc. London, vol. 4, p. 66, 1847.

TREMATIS ELLIPTOPORA Cooper, new species

Plate 11, H, figures 15-21

Shell small for the genus, represented by fragmentary specimens only; subcircular in outline with the surface marked by large, longitudinally elliptical pits increasing in size anteriorly. Pedicle valve subcircular in outline with a deep semicircular notch; beak concave, umbonal region gently concave, the concavity lessening anteriorly and laterally. Pedicle notch triangular, longer than wide, occupied by a deeply concave plate; actual pedicle opening wide and short, somewhat semicircular in outline. Brachial valve with swollen umbo and beak protruding slightly beyond the posterior margin; lateral profile moderately convex; umbonal slopes steep; median region swollen; anterior profile broadly convex and with steep lateral slopes.

Interior of pedicle valve with thickened ridge representing the strengthened inside of the concave plate; brachial interior with thickened posterior margin having a more or less deep triangular pit under the beak. Musculature not preserved in either valve. All specimens too incomplete to measure.

Types.—Holotype: 116809c; figured paratypes: 116809a,d; unfigured paratypes: 116809b,e-h.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by the large size of the pits which are a feature of the ornamentation. The pits are elliptical or oval in outline with the long axis parallel to the shell length. The elevated space between pits is relatively broad. Pits on the umbo are very small. The arrangement of pits is crudely quincuncial. The large size and form of the pits separate the species from other described forms.

A note about the pedicle valve is necessary because it is not certain that it belongs to this species. In color it is dark yellow like that of some of the other specimens which range from dark yellow to light brown. The pedicle valve is very thick shelled, which is another point in accord with the brachial valves to which it is assigned. The ornamentation, however, is not like that of the brachial valves. The pedicle valve shows small pits suggesting the youthful ornamentation of the umbonal region of the brachial valves. This ornamentation is very lightly impressed and does not occur around the margins. Possibly the ornamentation is preserved only on the more youthful parts of the pedicle valve.

The species is represented by fragmentary material only, consisting of several brachial valves but only the single pedicle valve.

TREMATIS FOERSTEI Cooper, new species

Plate 19, D, figures 15-19

T. huronensis FOERSTE (not Billings), Bull. Sci. Lab., Denison Univ., vol. 19, No. 3, p. 203, 1920.

Shell of about medium size for the genus, nearly circular in outline, lenticular in profile. Surface marked by stout radial lines, and concentric elements that de-

fine rows of small circular to quadrangular pits. Three to four rows of pits occupying 1 mm. at the front margin. Pits crudely concentric in arrangement but often upset by intercalations offsetting the pits enough to make one or more rows of pits appear opposite the crossbars in other rows.

Pedicle valve unevenly convex in lateral profile with the greatest convexity in the umbonal and median regions; anterior third flattened. Apex located about one-fourth to one-third the length anterior to the brachial beak or about one-fifth to one-sixth the length anterior to the posterior margin. Foramen short, semielliptical, about 4 mm. wide on the posterior margin and 3 to 4 mm. long, or in other words one-fifth to one-sixth the length. Umbonal region rounded, posterior slope steep, anterior slope long and flat, moderately steep. Lateral slopes flattened, moderately steep.

Brachial valve moderately convex in lateral profile but slightly more convex in anterior profile. Beak small, incurved; umbo narrowly swollen with steep, concave but short umbonal slopes. Median region somewhat inflated; lateral and anterior slopes gentle but the lateral ones the steeper.

Measurements in mm.—

| | Length | Width | Length foramen | Width foramen | Thickness |
|-------------------------------------|--------|-------|-------------------|------------------|-----------|
| Paratype (pedicle valve 109709c) .. | 16.7 | 18.6 | 2.5 | 4.5 | ? |
| " (109707b) | 18.5 | 20.3 | 2.5 | 5.0 | 6.0 |

Types.—Holotype: 109707d; figured paratypes: 109709a,d; unfigured paratypes: 109707a-c,e,f, 109709b,c,e.

Horizon and locality.—Upper 10 feet of the Platin group (Macy formation) or Barnhart formation in Ralls County, Mo.: Yaeger Farm, $5\frac{1}{2}$ miles southeast of New London; Buford Cave on the M. F. Meyer Farm, 2 miles west and $\frac{1}{2}$ mile north of New London; Conns Ford in the bed of Salt River about 4 miles northwest of New London in NW. corner sec. 33, T. 56 N., R. 5 W.

Discussion.—An examination of the figures of *T. huronensis* Billings shows that the Ralls County specimens under discussion are not conspecific. In the first place *T. huronensis* is a small species about $\frac{1}{2}$ inch or slightly more in length and $\frac{1}{2}$ inch or less in width. The pedicle valve is strongly concave, which incidentally may not be a faithful representation of the true condition of the species. The foramen of *T. huronensis* is figured as elongate, a deep and narrow gash in the posterior half of the shell that extends to the apex. These features combined with the more elongate form show clearly that the Ralls County specimens are not correctly identified with *T. huronensis*.

Comparison of the Missouri specimens with *T. ottawensis* is more difficult because only the brachial valve is known with certainty. The pedicle aperture of the pedicle valve figured by Hall and Clarke is a doubtful identification and cannot be relied upon. The brachial valve as indicated by Billings is a large shell, far larger than any of the Ralls County specimens. The ornamentation indicated by Billings is that of quadrangular pits opposed by the crossbars of adjacent series. The probability is that these are too regularly arranged in this fashion in the drawing. The few specimens of this species available for comparison show

slender, elevated radii and short concentric dashes forming the quadrangular pits, some of which appear opposite crossbars or opposite pits, patches of each occurring on the same shell. This feature is not unlike the ornamentation of *T. foerste*, but in that species the radial and concentric elements are not elevated, but are flattened.

Some features of *T. foerstei* such as the ornamentation and size are suggestive of *T. punctostriata* Hall from the Saltillo limestone at Clifton, Tenn., but *T. foerstei* has more convex brachial valve, stronger ornamentation, and an unrestricted foramen.

TREMATIS HURONENSIS Billings

Trematis huronensis BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 53, fig. 59 (adv. sheets 1862), 1865; Geol. Canada, p. 159, fig. 130, 1863.—LESLEY, Geol. Surv. Pennsylvania, Rep. P 4, p. 1198, figs., 1889.

Horizon and locality.—Black River limestone, Pallideau Islands, Lake Huron.

TREMATIS MINNEAPOLIS (Sardeson)

Productella minneapolis SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 332, pl. 4, figs. 11, 12, 1892.

Trematis huronensis SCHUCHERT (not Billings), Winchell and Schuchert, Geol. Minnesota, vol. 3, p. 368, fig. 29, 1893.

Horizon and locality.—Decorah formation (Spechts Ferry member-*Stictoporella* bed), Minneapolis, Minn.

TREMATIS PARVA Cooper, new species

Plate 19, E, figures 12-14

Species represented by three brachial valves only; small, broadly elliptical in outline; sides narrowly rounded, anterior margin broadly rounded. Gently convex in both profiles. Beak small, marginal, incurved. Umbo narrow, smooth, with a shallow sulcus originating at its anterior end; sulcus continued forward, widening gradually to the anterior margin. Posterolateral slopes to the margins steep. Lateral slopes moderately steep but anterior slope long and fairly gentle. Flanks bounding sulcus somewhat swollen. Surface marked by deep circular pits arranged in quincunx.

Measurements in mm.—Holotype, length 3.7, width 4.7.

Types.—Holotype: 109703; figured paratype: 109705a; unfigured paratype: 109705b.

Horizon and locality.—Chatham Hill formation in Virginia: Grayson Farm, north slope of Walker Mountain, 4 miles southwest of Bland, Bland County.

Lower Whitesburg formation in Tennessee: $\frac{1}{2}$ mile west of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Discussion.—This species is characterized by its small size and the quincunxial arrangement to the deep pits on the surface. The ornamentation is not quite like that of any other American species of the genus, and it is possible that the

pedicle valve when found will indicate a new genus. The definite median sulcus is another feature quite unlike that of *Trematis* ss.

TREMATIS ? SPINOSA Cooper, new species

Plate 11, I, figures 22-24

Known from the brachial valve only; thin shelled, light to dark brown in color, subcircular in outline; lateral and anterior margins strongly rounded; gently convex in lateral profile and with the greatest convexity in the umbonal region; anterior profile broadly convex with moderately steep slopes and swollen median region. Surface marked by densely crowded pits; margin marked by fine hair-like spines; spiny margins preserved in late growth varices. Interior with a small concave plate overhanging the umbonal cavity.

Type.—Holotype: 116810.

Horizon and locality.—Pratt Ferry formation: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This peculiar little shell is most closely allied to *T. ? parva* from the Grayson Farm in Virginia, although no spines were seen on the Virginia shell.

TREMATIS sp. 1

Plate 27, D, figure 9

This species is represented by two poorly preserved brachial valves that have somewhat the shape of *T. parva* but in which the pits, where visible, are more like those of true *Trematis* arranged in rows between longitudinal costellae. The best specimen is small, slightly wider than long, with a marginal beak and narrow, prominent umbo. The convexity is moderate in both profiles.

Measurements in mm.—117970, length 4.2, width 4.7.

Figured specimen.—117970.

Horizon and locality.—Whitesburg formation in Tennessee: $\frac{1}{2}$ mile west of Bulls Gap; $2\frac{1}{2}$ miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle.

TREMATIS sp. 2

A second undescribed species of *Trematis* is indicated by five specimens, all brachial valves, from Whitesburg formation in the railroad cut 1 mile southwest of Otes, Bulls Gap (T.V.A. 171-SE) Quadrangle, Tenn., where it occurs with *Ectenoglossa nymphoidea*. This species is strongly convex in both profiles and quite oval in outline. The greatest width is located anterior to the middle. The beak is strongly incurved and the umbo convex. The median portion is swollen and all the slopes to the margins are fairly steep. The costellae are very fine. Adjacent pits, in general, are arranged alternately, a pit falling opposite a crossbar. About 12 costellae appear at the front margin in the space of 1 mm.

Described specimens.—109702a-e.

TREMATIS sp. 3

Plate 19, C, figures 10, 11

This third species is represented by a fragment of the brachial valve preserving the umbonal region and part of the right side. The species is characterized by its broad umbo, the strong convexity, and broad flat costellae separating rows of longitudinally elliptical pits. The specimen was taken from the base of the Lower Edinburg formation (*Cyrtonotella* zone) in Virginia: about $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Figured specimen.—109704.

Genus **SCHIZOCRANIA** Hall and Whitfield, 1875**SCHIZOCRANIA FILOSA** (Hall)

Plate 19, F, figures 20, 21

Orbicula ? *filosa* HALL, Pal. New York, vol. 1, p. 99, pl. 30, fig. 9, 1847.

Schizocrania filosa Hall, BASSLER, U. S. Nat. Mus. Bull. 92, p. 1144, 1915.—FOERSTE, Bull.

Sci. Lab., Denison Univ., vol. 19, No. 3, p. 202, 1920.

This is a rare species in rocks older than the Trenton limestone, but it is reported as common by Foerste in the upper 10 feet of the Plattin group (Macy formation) or Barnhart formation of Ralls County, Mo., at several localities. One of Foerste's specimens is figured which shows a number of individuals of different size attached to a pedicle valve of *Rafinesquina* cf. *R. elongata*. This early occurrence of *Schizocrania* and *Rafinesquina* ss. leads to the suspicion that the top of the Plattin here is post-Black River in age and belongs to the Barnhart formation.

Figured specimen.—109711.

Family DISCINIDAE Gray, 1840

Discinacea having a pedicle notch in early stages which is closed posteriorly by later growth to leave a more or less long slit partially closed by a listrium.

Subfamily ORBICULOIDEINAE Schuchert, 1929

Foramen encased in a long pedicle tube.

Genus **ORBICULOIDEA** D'Orbigny, 1847

Orbiculoidea D'ORBIGNY, Compt. Rend. Acad. Sci. Paris, vol. 25, p. 269, 1847.

ORBICULOIDEA EXIMIA Cooper, new species

Plate 13, C, figure 5; plate 20, D, figures 11-23

Shell fairly large, nearly circular in outline, biconical. Color shiny brown but often with a blue-gray tarnish. Pedicle valve forming a low cone with a sharp, nearly central apex directed slightly anteriorly. Slope anterior from the apex gently concave; posterior slope also gently concave but somewhat less steep than

the anterior slope. Lateral slopes concave, moderately steep. Foramen located about 3 mm. posterior to the apex. Slit formed by migration of foramen, about 3 mm. long, narrow, but widening slightly near the foramen.

Brachial valve forming a depressed cone but with the center or apex located about one-third the valve length from the posterior margin. Apex small, nearly smooth and bluntly rounded. All slopes to the margins gentle.

Surface of both valves marked by concentric undulations which are more elevated and regular on the pedicle valve and more gently rounded, lower and crowded on the brachial valve and near the margins.

Measurements in mm.—Holotype, length 18.0, width 17.0, height 5.5.

Types.—Holotype: 109632f; figured paratypes: 109428a,b, 109632a,b,d,e, 109634b, 117953a; unfigured paratypes: 109632c, 109633a-e, 109634a,c-f, 117953b-j.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplecta gouldi* zone) in Oklahoma: Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S.; R. 1 E., Criner Hills, Carter County.

Discussion.—This species is characterized by the biconical form and the nearly central position of the beak of the brachial valve. In this latter respect it differs strongly from all species of *Schizotreta*. Only one other species of *Orbiculoidea* was found in the formations represented in this monograph. It is not comparable to *O. lamellosa* (Hall) from the Trenton limestone, which is a much smaller species.

ORBICULOIDEA LINVILLENSIS Cooper, new species

Plate 20, B, figures 4, 5

Small, longitudinally broadly elliptical in outline with the length slightly greater than the width. Sides slightly flattened, anterior and posterior rounded. Surface marked by fine concentric lines as usual in the genus.

Pedicle valve with apex located at center; anterior and posterior slopes moderately convex, the posterior slope the steeper of the two. Lateral slopes flattened, moderately steep. Pedicle groove long and slender, not quite 2 mm. in length. Apex erect.

Brachial valve in the form of an irregular cone, the apex located one-third the length from the posterior margin. Anterior slope steep and deeply concave; posterior slope steep but nearly flat in profile. Lateral slopes flat but steep. Two muscle scars indistinctly visible anterolateral of the apex, and from these scars 2 pallial trunks extend, swing together for the length of about 1 mm., then diverge slightly and extend nearly to the front margin.

Measurements in mm.—Holotype, pedicle valve: length 9, width 8.2, apex 4.4 anterior to posterior margin. Paratype, brachial valve (109637b): length 8.3, width 7.4, apex located 2.7 mm. anterior to the posterior margin.

Types.—Holotype: 109637a; paratype: 109637b.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Discussion.—This species is characterized by the central position of the pedicle

apex, the slender pedicle groove and the posterior position of the apex in the brachial valve. This is a combination of characters not seen in any of the other species in the Appalachians.

Genus *SCHIZOTRETA* Kutorga, 1848

Schizotreta KUTORGA, Verhändl. Russ.-Kais. Min. Ges. St. Petersburg for 1847, pp. 260, 272, pl. 7, fig. 6, 1848.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 135, 1892.—GIRTY, Journ. Washington Acad. Sci., vol. 18, No. 5, pp. 128-142, 1928.

Acrosaccus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 258, 1928.

The name *Schizotreta* is applied to brachiopods having a subconical pedicle valve and a brachial valve that is nearly flat or even somewhat concave. Kutorga's type species, *Orbicula elliptica*, is a small shell having a nearly flat brachial valve. Furthermore, the brachial valve has the beak situated in a position distinctly posterior to the middle. The beak is not marginal, but in the type species and in all the American specimens here referred to this genus the beak is located in a submarginal position, often less than a millimeter anterior to the margin.

Specimens of Dr. Willard's genus *Acrosaccus* have the same characters as those of *Schizotreta*. Willard's genus was created for shells supposed to be related to *Acrothele* but without or rarely with a false cardinal area in the pedicle valve and with the brachial protegulum near the posterior margin. Although the type specimens do not show the pedicle opening it is stated that the presence of a "pedicle tube proved the relationship to the Acrotretacea rather than the Discinacea." Actually the pedicle aperture in the numerous specimens now available is quite discinoid, and *Acrosaccus* proves to be a synonym of *Schizotreta*.

SCHIZOTRETA CANADENSIS Wilson

Schizotreta canadensis WILSON, Geol. Surv. Canada, Bull. 8, p. 25, pl. 2, figs. 14, 15, 1946.

Types.—Holotype: G.S.C. 6373; paratype: G.S.C. 6373a.

Horizon and locality.—Leray-Chaumont formation, in Ontario, Canada: Lot 2, Concession IV, Cumberland Township.

SCHIZOTRETA CORRUGATA Cooper, new species

Plate 21, C, figures 7-20; plate 28, G, figures 24-28

Shell of about medium size for the genus, longer than wide, depressed conical in profile and marked on the exterior by strong, elevated concentric ridges.

Pedicle valve forming a depressed, asymmetrical cone; posterior slope steep, short, flat in profile; anterior slope nearly 3 times the length of the posterior slope, almost flat or slightly concave in lateral profile; apical angle greater than a right angle. Lateral slopes flat and fairly steep. Pedicle groove about 1.5 mm. long, moderately wide; foramen generally small.

Brachial valve roundly elliptical in outline, the length being slightly greater than the width; beak small, smooth, located $\frac{1}{2}$ mm. or less from the posterior margin; posterior slope steep; anterior slope very gently convex; anterior profile gently convex. Ornamentation variable, often extreme; ridges variable in

elevation and distance, occasionally fairly regular, more often slightly wavy; ridges occasionally attaining $\frac{1}{2}$ mm. or more in height.

Pedicle interior: Foramen entering valve near the posterior margin; slit forming a low ridge on inside anterior to foramen and extending into umbonal cavity. Muscles not visible in material at hand.

Brachial interior with posterior margin thickened and incurved; inner surface of posterior margin with a crescent-shaped mark convex inward. Lateral and anterior margins flat. Center of valve occupied by 2 large muscle scars, oval in outline and with their small ends directed posterolaterally. Anterior occupied by 2 narrowly diverging thin pallial trunks.

Growth.—Young specimens definitely oval in outline and marked by fine, somewhat distant elevated ridges. Posterior slope lengthened only slightly.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Paratype (pedicle valve 116808a) | 6.5 | 5.6 | ? |
| " (brachial valve 117972b) | 10.0 | 9.0 | 0.75 ? |

Types.—Holotype: 116808-1; figured paratypes: 116808a,c-e,g-k; 117972a,b; unfigured paratypes: 116808b,f, 117972c-e.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—The ornamentation with its highly elevated ridges is distinctive in this species and unlike any other known. The development of the ornamentation is interesting. On the anterior slope, continuous ridges alternate with short ridges apparently formed at the front of the valve. These short ridges die out on the flanks.

SCHIZOTRETA MICROTHYRIS Cooper, new species

Plate 20, A, figures 1-3; plate 22, D, figures 6-9; plate 22, I, figure 16; plate 27, A, figures 1-3

Shell large, nearly circular in outline, the length slightly greater than the width. Pedicle valve in lateral profile forms a low cone with long concave anterior slope and shorter, steeper, but flat posterior slope. Apex located somewhat less than one-third the length from the posterior margin. Beak small and erect. Pedicle groove short, narrowly elliptical and measuring slightly less than 2 mm. in length. Lateral slopes steep, very gently concave.

Brachial valve forming an irregular low cone with the apex located about one-fourth the length anterior to the posterior margin. Apex low and rounded, anterior slope nearly flat or gently concave; posterior slope short, concave, and steep.

Surface of both valves marked by crowded, fairly regular elevated concentric lines.

Measurements in mm.—The holotype, a pedicle valve, measures 21.7 in length, 19.5 in width; the posterior slope is 8 long but the apex is 6 in a straight line anterior to the posterior margin. A small brachial valve (paratype 97547a) is 12.5 long by 11.5 wide, the apex is 3 anterior to the posterior margin in a straight

line; another brachial valve (paratype 116804a) is 19.7 long, 20.0 wide; the apex is 3 anterior to the posterior margin.

Types.—Holotype: 109640; figured paratypes: 97547a-c, 116803a, 116804a; unfigured paratype: 116803b.

Horizon and locality.—Oranda formation in Virginia: Along the railroad $\frac{1}{4}$ to $\frac{1}{2}$ mile east of Strasburg Junction; on U. S. Highway 11, 1 and 2 miles southwest of Strasburg; Virginia Highway 55, 0.4 mile west of U. S. Highway 11 on the north edge of Strasburg, Strasburg (15') Quadrangle. $\frac{1}{4}$ mile below the dam on the Shenandoah River, 1 to $1\frac{1}{2}$ miles north of Edinburg, Edinburg (15') Quadrangle.

Oranda formation in Pennsylvania: 1 mile northwest of Guilford Springs, Chambersburg (15') Quadrangle.

Discussion.—This species is characterized by its large size and the short, elliptical pedicle groove of the pedicle valve. It is unlike any other species yet known in the Appalachian Valley, differing from *S. subconica* in larger size and circular outline.

Some specimens show obscure details of the interior, but the valves are usually so badly exfoliated that considerable uncertainty attends their interpretation. Two specimens show the position of the pedicle groove on the interior but its shape is not determinable.

SCHIZOTRETA PANNEA (Willard)

Acrosaccus panneus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 259, pl. 3, fig. 3, 1928.

This is a large species based on a single pedicle valve which is distinguished from *S. shuleri* (Willard) by its much wider apical angle. A single specimen (109657) in the National Museum collections is referred somewhat doubtfully to this species.

Type.—Holotype: M.C.Z. 8592.

Horizon and locality.—Effna formation in Virginia: McNutt Quarry, 12 miles southwest of Bland, near Sharon Springs, Burkes Garden (15') Quadrangle.

SCHIZOTRETA PAPILLIFORMIS Ruedemann

Schizotreta papilliformis RUEDEMANN, New York State Mus., Bull. 42, p. 570, pl. 1, figs. 3-5, 1901.

Horizon and locality.—Normanskill formation in New York: At Mount Merino, near Hudson.

SCHIZOTRETA POSTEROCONVEXA Cooper, new species

Plate 28, B, figures 5, 6

Specimen represented by two pedicle valves only; subcircular to slightly longitudinally elliptical in outline; conical in profile with the apex located at about the center. Posterior slope long and fairly strongly convex; anterior slope long,

deeply concave just anterior to the beak but the concavity flattening anteriorly. Greatest convexity of posterior slope located in vicinity of pedicle groove and foramen or for a distance of about 2 mm. Sides straight and steep, forming an angle of 95° . Pedicle slit about 1.5 mm. in length, narrow and confined to the convex area posterior to the beak. Surface marked by fine, elevated, evenly spaced ridges, about 8 to the millimeter at the front margin.

Measurements in mm.—Holotype, length 9.7, width 8.0+, thickness 3.9.

Types.—Holotype: 116801b; paratype: 116801a.

Horizon and locality.—Base of Athens formation (beds with *Christiania*) in Tennessee: 0.2 mile southeast of Britton Church, $2\frac{1}{2}$ miles northeast of Calhoun, Calhoun (T.V.A. 125-SW) Quadrangle.

Discussion.—This species is characterized by the strongly convex postumbonal region and posterior slope and the deeply concave umbonal region. In these respects it differs from *S. shuleri* which it strongly resembles.

SCHIZOTRETA SHULERI (Willard)

Plate 19, B, figures 7-9; plate 21, D, figures 21, 22

Acrosaccus shuleri WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 259, pl. 3, figs. 1, 2, 1928.

Shell of about medium size for the genus; exterior marked by strong, even, elevated, concentric ridges increasing in size gradually on the margins; about 5 ridges to the millimeter. Marginal ridges thickest on posterolateral edges.

Pedicle valve forming a moderately high, asymmetrical cone with the apex located posterior to the middle. Posterior slope in lateral profile shorter than the anterior slope and steep; anterior slope less steep than the posterior one but considerably longer and very faintly convex; apical angle about 90° . Foramen not preserved, but indications point to its position just posterior to the apex; pedicle tube about 2 mm. long or slightly longer.

Brachial valve almost circular and nearly flat; convex in the umbonal region but flattening anteriorly; beak smooth, small, located about 0.5 mm. anterior to the posterior margin.

Measurements in mm.—Pedicle valve (hypotype 109699a): length 9.7, width 9.5, thickness 3.9, posterior slope 5.0, anterior slope 8.0, lateral slopes 5.5; brachial valve (hypotype 109699c): length 8.8, width 8.0.

Types.—Lectotype: M.C.Z. 8581 (brachial valve); paratype: M.C.Z. 8591 (pedicle valve); figured hypotypes: 109699a,c, 117969a,b.

Horizon and locality.—Effna formation in Virginia: At McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Rich Valley formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: On the south side of the road, 0.2 mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Discussion.—This species was based on two poorly preserved specimens which were thought to have relationships with *Conotreta* and its allies. The pedicle

valve preserves its shape fairly well, but details of the pedicle opening and slit are absent. The brachial valve which is here selected as lectotype shows the outline, profile, and details of the ornamentation. *Schizotreta shuleri* is similar to *S. posteroconvexa* but does not have as strongly a convex posterior slope. The species is also suggestive of *S. corrugata* but is not so coarsely ornamented.

SCHIZOTRETA SUBCONICA Cooper, new species

Plate 20, C, figures 6-10; plate 21, E, figures 23-32

Shell of medium size for the genus, longitudinally elliptical in outline; surface marked by fine, even slightly elevated concentric lines.

Pedicle valve forming an eccentric cone with the apex about one-sixth the length anterior to the posterior margin. Posterior slope flat, short and steep, slightly less than 2 mm. long in the holotype; anterior slope long and flat, measuring about 5 mm. in the holotype. Lateral slopes steep, forming an angle of about 115° . Pedicle slit small, about 1 mm. long, narrow; foramen small.

Brachial valve longer than wide, gently convex in lateral profile, with the greatest convexity in the umbonal region; beak submarginal, smooth; lateral slopes gentle.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|-------|-----------|
| Holotype | 6.2 | 5.6 | ? |
| Paratype (pedicle valve 109646b) | 7.8 | 7.7 | 0.90 |
| “ (“ “ 109646a) | 6.8 | 6.3 | 1.5 |
| “ (brachial valve 109646f) | 8.6 | 7.6 | 1.5 |

Types.—Holotype: 116805a; figured paratypes: 109646b,d,e,f,g, 116805b-e; unfigured paratypes: 109646a,c,h-j.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its fairly high conical profile, elliptical form, and the fine, uniformly even character of the ornamentation. In the latter respect it suggests *S. posteroconvexa* but differs in having a flat posterior slope and smaller pedicle slit. This species is more finely ornamented than *S. shuleri* and is quite unlike *S. willardi* in profile, outline, and ornamentation.

SCHIZOTRETA WILLARDI Cooper, new species

Plate 11, C, figure 5; plate 19, A, figures 1-6; plate 21, F, figures 33-41

Shell fairly large for the genus, depressed conical in profile, circular in outline; brachial valve gently concave; surface marked by fairly even, elevated concentric lines, often crowded in the posterolateral region.

Pedicle valve with the apex slightly posterior to the center; posterior slope long and gently convex; anterior slope long and gently concave, the greatest concavity located at the umbo just anterior to the beak; lateral slopes long and gently concave. Pedicle slit short and fairly wide, tear-shaped in outline with the acute apex anterior in position; floor of slit marked by a deep groove; for-

men small and posterior margin of slit overhanging the opening. Inside the pedicle valve the foramen enters the shell about 1.5 mm. from the posterior margin and forms a tube that makes a ridge anterior to the umbonal chamber. A short ridge occurs anterior to the pedicle tube and in the umbonal chamber divides 2 muscle impressions.

Brachial valve gently convex in the umbonal region but flattened to concave anteriorly; posterior slope short, about 1 mm. in length in an adult shell, slightly concave and extended in about the same plane as the anterior part of the shell. Beak small, smooth and with a finely ornamented umbo; anterior slope convex and somewhat swollen in the posterior portion but becoming gently concave anteriorly; posterolateral region reflected in a brachial direction and thus producing concave lateral slopes. Details of the interior not preserved.

Measurements in mm.—

| | Length | Width | Thickness |
|---------------------------------------|--------|-------|-----------|
| Paratype (pedicle valve 109697c)..... | 7.6 | 7.5 | 1.0 ? |
| " (brachial valve 109697e) | 11.0 | 12.0 | ? |

Types.—Holotype: 109697b; figured paratypes: 109660a, 109697c,e-g, 116806a-c,e,f,g; unfigured paratypes: 109697a,d, 116806d,h,i.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its depressed form, short and tear-shaped pedicle slit, and the anterior concavity of the brachial valve. In these respects it is quite unlike any of the species herein described.

SCHIZOTRETA sp. 1

Plate 19, G, figure 22

This is a small species slightly more than 6 mm. in diameter and forming a high, irregular cone. The anterior and posterior slopes are nearly equal, but the latter is slightly shorter and steeper. The apex is bluntly rounded. The pedicle groove is long. The surface is marked by fine, even concentric lines.

Figured specimen.—109650.

Horizon and locality.—Hogskin member of the Lincolnshire formation (upper 30 feet) in Tennessee: 4½ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Superfamily CRANIACEA Waagen, 1885

Family CRANIIDAE Gray, 1840

Usually calcareous shells cemented by the pedicle valve and with more or less conical brachial valve.

EOCONULUS Cooper, new genus

(Greek *eos*, early; *conus*, cone)

Minute to small, misshapen cones with the apex on the posterior side; posterior margin nearly straight; interior of brachial valve with a large, oval muscle

scar located in the posterolateral extremities. Shell substance impunctate, corneous.

Genotype.—*Eocomulus rectangulatus* Cooper, new species.

Discussion.—This peculiar little shell occurs in abundance in the residues from the acetic acid etching of the Pratt Ferry limestone. The specimens are usually without an apex, which must have been easily exploded by the carbon dioxide resulting from the etching. At present the pedicle valve, which was undoubtedly attached, is not known. The genus occurs in the Pratt Ferry limestone and in the basal beds of the Botetourt formation in Virginia.

This genus differs from *Petrocrania* in its impunctate and "chitinophosphatic" shell and the simplicity of its interior. It is undoubtedly an early form of the Craniidae but occurs with undescribed normal examples of *Petrocrania*.

EOCONULUS RECTANGULATUS Cooper, new species

Plate 10, B, figures 11-13

Shell small to minute with the posterior margin nearly straight and slightly wider than the anterior margin; sides nearly straight to strongly rounded; anterolateral and posterolateral extremities narrowly rounded. Anterior and posterior slopes subequally steep; apex slightly eccentric.

Measurements in mm.—

| | Length | Width | Height |
|--------------------------|--------|-------|--------|
| Holotype | 1.1 | 1.4 | 0.5 |
| Paratype (116840b) | 1.2 | 1.6 | 0.9 |
| " (116840c) | 1.2 | 1.4 | 0.8 |
| " (116840d) | 1.4 | 2.0 | 1.2 |
| " (116840e) | 1.4 | 2.1 | 0.8 |

Types.—Holotype: 116840a; figured paratype: 116840b; unfigured paratypes: 116840c-e.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—Another species occurs in the Botetourt limestone of Virginia on the south side of the road 0.2 mile east of Strasburg Junction. This is a large species differently shaped from *E. rectangulatus*, but the specimens are not good enough for description. The members of this genus are readily distinguished from the usual members of the Craniidae by their shell substance.

Genus ACANTHOCRANIA Williams, 1943

Acanthocrania WILLIAMS (J. Steele), U. S. Geol. Surv. Prof. Pap. 203, p. 71, 1943.

This name was proposed to include *Cranias* "ornamented by fine papillae or fine spines." Williams designated *Crania spiculata* Rowley as the type of the genus.

This genus is widely distributed and is fairly abundant in the Ordovician. It also occurs in the higher rocks. At present the pedicle valve of the genus is not

known; it may have been very thin like *Philhedrella* and therefore not well preserved.

The name *Choniopora* may preoccupy the present one as already pointed out by Williams, but until the interior of that genus is made known Williams' generic name is preferred. *Choniopora* was originally thought to be a bryozoan colony but was later shown by Geinitz to have the shell structure of the Craniidae; the internal musculature still remains unknown.

ACANTHOCRANIA CUMBERLANDENSIS (Foerste)

Plate 26, D, figures 9-11

Crania granulosa cumberlandensis FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 16, p. 41, pl. 5, fig. 8, 1910.

Types.—Lectotype: 87157a; paratypes: 87157b (c, Foerste, 1910).

Horizon and locality.—Wells formation in Tennessee: $1\frac{1}{4}$ miles southwest of Cumberland City, in Stewart County.

ACANTHOCRANIA ERECTA Cooper, new species

Plate 26, G, figures 16, 17

Shell known only from brachial valve, of about medium size for the genus, nearly circular in outline, subconical in profile and with a nearly central apex. Sides flat in profile, moderately steep. Surface covered by short, blunt spines.

Measurement in mm.—Holotype, length 9, width 9.5, height 4.

Type.—Holotype: 109789.

Horizon and locality.—Bromide formation (Mountain Lake member?) in Oklahoma: NW $\frac{1}{4}$ sec. 27, T. 1 S., R. 2 E., midway between Dougherty and Davis.

Discussion.—This species can be distinguished readily from *A. granulosa* and *A. setigera* by its nearly symmetrically conical form and profile and by the greater height of the cone. The single specimen representing this species is also marked by low ridges, produced by the uneven surface of the host, which extend from the posterior side to the anterior side.

ACANTHOCRANIA GRANDIS Cooper, new species

Plate 26, A, figures 1-3

Species known from brachial valve only; large for the genus, crudely transversely elliptical in outline; conical in both profiles; later profile unsymmetrically conical, the anterior slope long and gently convex; posterior slope short, steep, and concave; apex located about one-fifth the length from the posterior margin; break smooth and slightly curved. Anterior profile a symmetrical cone with straight and steep sides. Surface covered by spines about 1.25 mm. in length.

Measurements in mm.—Holotype, length 15.2, width 17.4, height 6.6.

Type.—Holotype: 116838.

Horizon and locality.—Base of Benbolt formation in Virginia: On the west

slope of the hill $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle.

Discussion.—This species is characterized by its large size, unsymmetrical form in lateral view, and densely matted spines. In these respects it differs from all other species described herein.

ACANTHOCRANIA GRANULOSA (N. H. Winchell)

Crania granulosa N. H. WINCHELL, 8th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 63, 1880.—SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 343, 1892.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 373, pl. 29, figs. 34, 35, 1893.

Horizon and locality.—Decorah formation, Minneapolis, Minn.

ACANTHOCRANIA OKLAHOMENSIS Cooper, new species

Plate 27, H, figures 18-20

Shell fairly large for the genus, subcircular in outline, conical in both profiles; apex very slightly posterior to the center; lateral profile with steep, nearly flat anterior slope; posterior slope steeper than the preceding, fairly deeply concave just posterior to the beak but nearly flat posteriorly. Anterior profile with flat and only moderately steep slopes. Surface marked by very fine spines.

Measurements in mm.—Holotype, length 9.7, width 10.2, height 3.7.

Types.—Holotype; 116837a; figured paratypes: 116837b-d.

Horizon and locality.—Bromide formation (Pooleville member—bed 2) in Oklahoma: West of Nebo store in sec. 22, T. 2 S., R. 3 E., Murray County.

Discussion.—This species is unlike *A. subquadrata* from the Bromide formation in having a more symmetrical cone and in lacking the well-marked, triangular posterior slope. It also appears to be a larger shell.

ACANTHOCRANIA SETIGERA (Hall)

Plate 25, A, figures 1-5

Crania setigera HALL, Descr. new species Crinoidea and other fossils, p. 12, 1866; 24th Rep. New York State Cab. Nat. Hist., p. 220, pl. 7, fig. 15, 1872.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pl. 4, H, figs. 14-16, 1892.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 372, pl. 29, figs. 32, 33, 1893.—GRABAU and SHIMER, N. Amer. index fossils, vol. 1, p. 207, figs. 241e-f, 1907.

Figured specimens.—24739, 24743a.

Horizon and locality.—Platteville and Decorah formations, Wisconsin and Minnesota.

ACANTHOCRANIA SPINOSA Cooper, new species

Plate 26, H, figures 18, 19

Shell small for the genus, irregular in form, but crudely circular in outline. Greatest height at the middle. Apex smooth, small, located above the posterior margin and behind the middle of the valve, depressed below the highest point. Posterior slope short and steep. Surface covered by spines, which are about $\frac{1}{2}$ mm. in length near the margin.

Measurements in mm.—Holotype, length 4, width 5, height 2.

Types.—Holotype: 109795; paratype: 109796.

Horizon and locality.—Edinburg formation (Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle; Effna formation: Lower part McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Discussion.—One specimen of this species is a silicified brachial valve showing the spines well. The species can be recognized and differentiated from other known species by the peculiar profile in which the greatest height of the valve is at the middle with the apex posterior, approximately marginal and depressed below the highest point.

ACANTHOCRANIA SUBQUADRATA Cooper, new species

Plate 26, I, figures 20-25; plate 27, B, figures 4-7

Shell small, conical in profile, subquadrate in outline. Apex about one-third the length anterior to the posterior margin. Lateral and anterior margins broadly rounded; posterior margin nearly straight. Lateral profile with strongly convex anterior slope and slightly concave and steep posterior slope. Surface marked by very fine spines. Interior with large posterior muscle scars elongate-elliptical in outline. Central scars smaller and more circular. Pedicle valve unknown.

Measurements in mm.—The holotype (109759b) is 9.7 long, 8.8. wide, and 2.7 high. The apex is located 3.7 anterior to the posterior margin.

Types.—Holotype: 109759b; figured paratypes: 109759c,d, 109793, 116836; unfigured paratypes: 109759a,e.

Horizon and locality.—Bromide formation (upper Mountain Lake member) in Oklahoma: On Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County. Bromide formation (Pooleville member—*Lonchodomas* zone) in Oklahoma: Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—This species differs from *A. setigera* in its smaller size, much finer spines, and subquadrate form. It differs from *A. erecta* in its lower valve and finer spines.

ACANTHOCRANIA sp. 1

Plate 27, F, figures 12-14

Shell forming a low cone with apex slightly posterior to the middle; lateral profile with moderately long, convex anterior slope; posterior slope shorter, steeper, and nearly flat except for a short concave area just posterior to the beak; anterior profile with nearly flat, moderately steep slopes. Surface marked by very fine spines.

Measurements in mm.—116839, length 13.0, width 13.2, height 4.8.

Figured specimen.—116839.

Horizon and locality.—Lebanon formation (*Doleroides* zone) in Tennessee: On U. S. Highway 70N opposite Fairview Service Station, $\frac{1}{2}$ mile west of Rome, Smith County.

Discussion.—This species is characterized by its circular form, nearly symmetrical conical profiles, and very fine spines.

Genus **PETROCRANIA** Raymond, 1911

Petrocrania RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 229, 1911.

This genus is of rare occurrence in early Middle Ordovician rocks except locally, where it may be common. As far as known no member of this genus has yet been taken from high Pogonip or early Chazyan rocks. The oldest species, therefore, is *Petrocrania prona* (Raymond) from the Crown Point limestone of New York.

A point of considerable interest in connection with species of *Petrocrania* found in the rocks under consideration is the fact that at least as far as the National Museum collections are concerned no pedicle valves have yet appeared. In discussing *P. ulrichi*, Winchell and Schuchert (1895, p. 375) remark on this fact but suggest that the pedicle valve was convex. This suggestion was supported by the statement that the two valves figured by Hall and Clarke appeared to have different musculature and indicated pedicle and brachial valves. The musculature as restored for the pedicle valve is not usual for the genus, and it is probable that the restoration and identification of the valve are in error.

PETROCRANIA CICATRICULA Willard

Petrocrania cicatricula WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 260, pl. 3, fig. 4, 1928.

Type.—Holotype: M.C.Z. 8590.

Horizon and locality.—"Ottosee" (probably Hogskin): Quarry north of Luttrell, Tenn.

PETROCRANIA DIXONENSIS Cooper, new species

Plate 27, E, figures 10, 11

Under this heading is placed a single species of fairly large size from the Platteville limestone. It has the following characters: Elliptical in outline with the width about $1\frac{1}{4}$ times the length, posterior margin short and flat; lateral and anterior margins broadly rounded; beak almost marginal; posterior slope steep, and slightly concave; anterior slope long, strongly convex; anterior profile broadly convex. Distance of beak from posterior margin 1.5 mm.

Measurements in mm.—Holotype, length 13.6, width 16.5, thickness 3.

Type.—Holotype: 45215.

Horizon and locality.—Platteville formation in Illinois: At Dixon, Dixon (15') Quadrangle.

Discussion.—This species differs from *P. trentonensis* Hall in its large size, the more marginal apex, and the strongly inflated and proportionately longer anterior slope.

PETROCRANIA HALLI (Sardeson)

Plate 25, D, figures 11, 12

Crania halli SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 328, pl. 4, figs. 8-10, Apr. 9, 1892.

Craniella ulrichi HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 181, pl. 4, I, figs. 1, 2, 1893.

C. ? ulrichi Hall and Clarke, WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 375, pl. 29, figs. 38, 39, 1893.

Specimens of *P. halli* labeled by Dr. Sardeson and deposited in the National Museum have all the significant characters of *P. ulrichi*. The two species are here regarded as synonyms, and the name *P. halli* has precedence. Much uncertainty exists about the dates of some of the *Minnesota* species, but in this case it seems clear that Sardeson's name should supercede *P. ulrichi*. The letter of transmittal of Pal. New York, vol. 8, pt. 1, is dated May 1892, whereas Sardeson's paper appeared in the early part of April. Winchell and Schuchert state that it ". . . is well known, part 1 of that volume [Pal. New York, vol. 8] was printed nearly two years before it was published." As the validity of a species depends on its date of publication, the fact mentioned by Winchell and Schuchert has no bearing on the standing of the species.

Figured specimens.—24218a, 45218a.

Horizon and locality.—Decorah formation (Specfts Ferry member—*Stictoporella* bed, to Ion member—*Phylloporina* bed) in Minnesota: St. Paul and vicinity.

PETROCRANIA HAMILTONIAE (Hall)

Plate 25, E, figures 13, 14

Crania hamiltoniae HALL, 13th Rep. New York State Cab. Nat. Hist., pp. 76, 77, figs. 4, 5, 1860; Pal. New York, vol. 4, p. 27, pl. 3, figs. 17-23, 1867.

Impressions of the interior of this species are introduced to show the pallial marks and musculature for comparison with Ordovician species.

Figured specimens.—116834b,c.

Horizon and locality.—Basal Ludlowville (Stone Mill member) in New York: At 1,265 feet elevation on the road 1 mile southwest of Randallville, Morrisville (15') Quadrangle.

PETROCRANIA INFLATA Cooper, new species

Plate 25, I, figures 24, 25; plate 25, J, figures 26-35; plate 26, F, figures 14, 15

Small to medium size for the genus, forming a rounded ellipse in outline with the width slightly greater than the length. Profile an irregular cone with the apex pointing posteriorly and overhanging the posterior slope. Apex located at about one-fourth the length from the posterior margin. Posterior slope steep and slightly concave; anterior slope steep and strongly convex in profile. Surface marked by concentric undulations, in some instances with irregular patterns induced by the ornamentations of the host.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 9.3 | 10.8 | 4.0 |
| Paratype (109786a) | 11.2 | 11.7 | 4.7 |

Types.—Holotype: 109785a; figured paratypes: 109758, 109767, 109783c, 109785e; unfigured paratypes: 109783a,b,d,e, 109785b-d, 109786a.

Horizon and locality.—Bromide formation (Pooleville member—*Oxoplectra gouldi* zone) in Oklahoma: Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Carter County, Criner Hills; (183 feet below massive limestone), second dam on Spring Creek, north of Woodford, Murray County.

Discussion.—This species is suggestive of *P. trentonensis* (Hall) but differs in its strongly inflated anterior slope.

PETROCRANIA ? MAGNA Cooper, new species

Plate 25, B, figures 6, 7

Shell very large for the genus, represented by brachial valve only, irregularly conical, broadly elliptical or crudely rectangular in outline, with the width about one-third greater than the length. Posterior margin nearly straight, lateral margins gently rounded; anterior margin bilobed because of a slight emargination near the middle. Strongly convex in profile, with the greatest height at about the middle. Apex posterior in position and overhanging the short, steep posterior slope. Anterior profile moderately convex. Sulcus, shallow, extending from a point near the apex to the front margin where it forms a slight indentation. Sulcus located to the left of valve center when apex is held away from the observer.

Measurements in mm.—Holotype, length 20, width 26.5, height 7.

Types.—Holotype: 109762.

Horizon and locality.—Effna formation in Virginia: Lower part of McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Discussion.—This species is not likely to be confused with any other known Middle Ordovician craniid because of its large size and peculiar form. As one of the earliest members of the genus, the great size is remarkable.

PETROCRANIA PRONA (Raymond)

Plate 25, F, figures 15-19

Crania prona RAYMOND, Ann. Carnegie Mus., vol. 3, p. 594, 1906.

Petrocrania prona RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, pl. 34, figs. 26-31, 1911.

Not *P. prona* Raymond, WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 260, pl. 1, fig. 6, 1928.

The shells from the quarry north of Luttrell identified as this species are incorrectly placed. It is a large species which cannot now be identified with any known species, but the material is inadequate to describe as new.

Types.—Cotypes: Carnegie Mus. 5441-5443; figured hypotype: A.M.N.H.

25046.

Horizon and locality.—Crown Point formation in New York: East side Valcour Island, Sloop Bay, and Chazy, Plattsburg (15') Quadrangle.

Mingan formation (zone 5) on Bald or Mingan Island, Mingan Group, St. Lawrence River, Quebec, Canada.

PETROCRANIA TRENTONENSIS (Hall)

Plate 27, G, figures 15-17

Crania trentonensis HALL, Descr. new species Crinoidea and other fossils, p. 12, 1866; 24th Rep. New York State Cab. Nat. Hist., p. 219, pl. 7, figs. 11, 12, 1872; Pal. New York, vol. 8, pt. 1, pl. 4H, figs. 21, 22, 1893.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 374, pl. 29, figs. 36, 37, 1893.

Type.—Hypotype: 116835.

Horizon and locality.—Martinsburg formation (Salona equivalent) in Virginia: On Virginia Highway 617=910, 0.15 mile north of Green Mount Church, 4 to 5 miles north of Harrisonburg, Broadway (15') Quadrangle.

PETROCRANIA sp. 1

Plate 22, G, figure 14; plate 25, H, figure 23

In the "Ottosee" facies near the base of the Lowville in the belt running along the Cumberland Front and in the high Chickamauga limestone in northwestern Georgia a small species of *Petrocrania* occurs on slabs in some abundance. Unfortunately, all the valves in the National Museum collection show the interior only, thus making it unwise to describe the species. The form of the valves is suggestive of *P. trentonensis*.

Figured specimens.—109776a, 109778.

Horizon and locality.—Ridley formation in Georgia: On U. S. Highway 27 just north of Chickamauga Creek, Kensington (T.V.A. 106-SE) Quadrangle.

Dryden formation in Tennessee: Lone Mountain-Tazewell road, 1½ miles northeast of Lone Mountain; road along Little Sycamore Creek, ½ mile northeast of west edge of Howard Quarter (T.V.A. 162-NW) Quadrangle; west side of the sharp loop on the road down Flint Creek, NW¼ center subquad., Powder Springs (T.V.A. 154-SW) Quadrangle.

PETROCRANIA ? sp. 2

Plate 25, C, figures 8-10

Species represented by a single brachial valve of small size; outline irregular; beak not discernible; both profiles broadly convex; posterior side the narrower. Interior with 2 large but indistinct muscle scars on the posterolateral extremities. Anterior with a short and low septum.

Figured specimen.—109770.

Horizon and locality.—Edinburg formation (base of the Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle.

Discussion.—The specimen in question is a silicified valve in which the interior

details are not clearly shown. The valve is also indefinite in shape, and the apex is not discernible. The large muscle scars in the rear of the shell are not clear but strongly suggest *Petrocrania*. The unusual feature of the valve is the low and short median septum. This may be a freak of silicification but seems to be a part of the valve.

PETROCRANIA sp. 3

Plate 25, G, figures 20-22

This is a small species or possibly the young of a larger one. The outline is somewhat trapezoidal. The largest specimen measures 7.2 mm. long, 7.7 mm. at the widest part which is well anterior to the middle, and nearly 4 mm. high. The apex is about three-fourths the length posterior to the front margin.

Figured specimens.—109766a,b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: From a deep well on the Jones Farm, sec. 22, T. 5 N., R. 3 E., Pottawatomie County.

Genus PHILHEDRA Koken, 1889

Philhedra KOKEN, Neues Jahrb. Mineral., Geol. and Paleont., Beil., Bd. 6, p. 465, 1889.

PHILHEDRA DEPRESSA Cooper, new species

Plate 26, B, figures 4, 5

Shell of a brachial valve of about medium size for the genus, nearly circular in outline and forming a low cone in lateral profile. Lateral margins gently rounded but anterior margin more strongly rounded and posterior margin nearly straight. Apex located two-fifths the length from the posterior margin. Beak and umbo smooth; beak directed posteriorly. Anterior slope only moderately steep and gently convex in profile. Posterior slope long and flattened just posterior to the apex, moderately steep. Lateral slopes slightly convex. Surface marked by distant strongly elevated costellae, 2 or 3 in the space of 1 mm. at the front margin. The apex is located 4 mm. anterior to the posterior line.

Measurements in mm.—Holotype, length 10.2, width 10, thickness 2.2.

Type.—Holotype: 109749.

Horizon and locality.—Prosser formation in Wisconsin: 25 feet above base of the Duck Creek Quarry, near Green Bay.

Discussion.—This species is distinguished from *Philhedra laelia* by its more nearly central beak and more distant costellae.

PHILHEDRA FERRUGINEA Cooper, new species

Plate 26, C, figures 6-8

Brachial valve circular in outline and forming a low cone with the apex slightly posterior to the center. Anterior slope slightly convex and gentle; posterior slope flat in profile, shorter and steeper than the anterior slope. Surface marked by numerous fine costellae 4 or 5 in a millimeter at the periphery. Apex located about 6 mm. anterior to the posterior margin.

Measurements in mm.—Holotype, diameter 14, height 3.5.

Type.—Holotype: 109750.

Horizon and locality.—Red Knobs formation in Tennessee: 7 miles northeast of Charleston, Calhoun (T.V.A. 125-SW) Quadrangle.

Discussion.—This species is characterized by its large size, circular outline, and its fairly high conical profile. Inasmuch as this is one of the earliest known species of the genus, its generally advanced form is exceptional. The specimen is as large as is commonly found in the Devonian, when species of this genus are abundant. It is larger than other Ordovician species and can be distinguished readily from *Philhedra laelia* and *P. minor* by this character as well as the very fine costellae.

PHILHEDRA MINOR Cooper, new species

Plate 26, E, figures 12, 13

Brachial valve small, slightly longer than wide, forming an eccentric cone. Apex smooth, located about one-fifth the length from the posterior margin, and overhanging the posterior slope. Anterior slope flattened, slightly inclined for half its length, but moderately steep and convex in its anterior half. Posterior margin nearly straight. Posterior slope steep and concave. Costellae nearly reaching the beak, increasing by implantation, threadlike and crowded at the front margin.

Measurements in mm.—Holotype, length 6.6, width 4.2, height 2.

Type.—Holotype: 109760.

Horizon and locality.—Pierce formation in Tennessee: Pierce Mill, Walter-hill, $7\frac{1}{2}$ miles north of Murfreesboro.

Discussion.—This species suggests *Philhedra laelia* (Hall) but differs in its more elevated form and much finer ornamentation. It is a more elevated cone and with finer ornamentation than *P. depressa*.

PHILHEDRA ? sp. 1

Plate 22, H, figure 15

This is the interior impression of a small species showing the characteristic pair of large muscles near the apex of the brachial valve. The specimen is 10.8 mm. long and 8.7 mm. wide. Details of the exterior are unknown.

Figured specimen.—109761.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: Near the northeast corner NW $\frac{1}{4}$ sec. 27, T. 1 S., R. 2 E., 3 miles northwest of Dougherty, Murray County.

Subclass PYGOCAULIA

Suborder ORTHOIDEA Schuchert and Cooper, 1932

Superfamily ORTHACEA Walcott and Schuchert, 1908

Family ORTHIDAE Woodward, 1852

Progressive and terminal Orthacea with interareas on both valves; delthyrium open in most genera; pseudodeltidium rare; muscle field of pedicle valve oval or

obcordate; ovarian impressions subreniform; vascula media subparallel. Brachial valve with simple cardinal process, rodlike brachiophores, divergent and without other support than the shell substance of the notothyrial platform; chilidial plates or chilidium rare.

Subfamily ORTHINAE Schuchert and Cooper, 1931

Progressive Orthidae having short and curved interareas in the pedicle valve.

Genus **ARCHAEORTHIS** Schuchert and Cooper, 1931

Archaeorthis SCHUCHERT and COOPER, Amer. Journ. Sci., vol. 22, p. 243, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 80, 1932.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 91, 1938.

ARCHAEORTHIS BICONVEXA Cooper, new species

Plate 31, B, figures 7-10

Shell of about usual size for the genus, wider than long; sides and anterior margin moderately rounded; hinge narrower than the midwidth which is the widest part; surface marked by strong, elevated, narrowly rounded costellae which increase by implantation and number 2 or 3 in a millimeter at the front margin. Costellae subfasciculate at the front margin.

Pedicle valve strongly convex in lateral profile and with the maximum curvature on the umbo; anterior profile narrowly domed but with sides moderately sloping. Beak strongly incurved; umbo rounded and swollen; median region swollen nearly to the anterior margin to form a poorly defined fold. Sides moderately steep; anterior slope steep. Interior with large teeth having deep crural fossettes. Lateral plates developed along the delthyrial margin. Delthyrial cavity deep; callosity anterior to muscle field short but extending to about the middle.

Brachial valve moderately convex in lateral profile and with the maximum depth just posterior to the middle; anterior profile gently and broadly convex; umbonal and postmedian regions swollen; lateral slopes moderately steep toward the posterolateral extremities. Anterior slope gentle. Median sulcus poorly defined throughout its length, shallow.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 5.9 | ? | 7.4 | 5.8 | 2.0 |
| Paratype (brachial valve 116852b) .. | ? | 4.8 | 5.9 | 4.0 | 1.2 |

Types.—Holotype: 116852a; figured paratype: 116852b.

Horizon and locality.—Limestone lens in the Womble shale in Oklahoma: 1,100 feet south and 700 feet west of the NE. corner sec. 3, T. 2 N., R. 19 E., Pushmataha County.

Discussion.—This species is featured by its deep pedicle valve and a brachial valve with only a very shallow sulcus developed. In the latter respect it differs from all the Canadian *Archaeorthis* described by Ulrich and Cooper which have a well-marked brachial sulcus.

Genus **ORTHAMBONITES** Pander, 1830

Orthambonites PANDER, Beitr. Geogn. Russ. Reiches, p. 80, 1830.

This name has long been under the synonymy of *Orthis* but was lately revived by Cooper (1942) for the biconvex orthids. The genus *Orthis* as restricted is a concavo-convex shell having some similarities to *Cyrtotella*. On the North American continent a few species only conform to the generic definition of restricted *Orthis*; consequently, the need of a name for the host of biconvex forms becomes apparent.

The species placed under *Orthambonites* in this monograph are actually a composite lot. Some of them conform closely to the description of the genus, but others obviously are more remotely connected to it. Many more species will have to be described and considerable work performed on the internal characters of a host of species now indifferently referred to *Orthis* before the true generic affinities of *Orthambonites* and its derivatives will have been made known.

As used here the genus *Orthambonites* is for biconvex orthids having a costate ornamentation and with orthoid cardinalia and the pedicle musculature of the Orthidae. A few of the species referred here do not conform strictly to this type, such as *O. bifurcatus*, *O. brachiophorus* with its unusually long brachiophores, *O. dinorthoides* with its elongate pedicle muscle field, and *O. subconvexus*.

ORTHAMBONITES ACUTIPPLICATUS (Raymond)

Plate 33, C, figures 8-11

Orthis acutiplicata RAYMOND, Amer. Journ. Sci., 4th ser., vol. 20, p. 370, 1905; Ann. Carnegie Mus., vol. 7, No. 2, p. 237, pl. 35, figs. 8-10, 1911.

Types.—Lectotype: Carnegie Mus. 5458; paratypes: Carnegie Mus. 5459, 5460.

Horizon and locality.—Day Point ? formation in New York: Southern end of Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

ORTHAMBONITES ANGULATUS Cooper, new species

Plate 36, C, figures 19, 20

Shell large for the genus, known only from the pedicle valve; wider than long; hinge forming the widest part; cardinal extremities produced into small, acutely angular ears; sides gently rounded; anterior margin fairly strongly rounded; surface costate, costae 17 in number, angular.

Pedicle valve moderately convex in lateral profile with the greatest convexity in the median region; anterior profile broadly convex, the median region somewhat narrowly rounded but the lateral slopes long and gentle; umbonal region slightly swollen, the swelling continued to the anterior margin as a low but indistinct fold. Interarea moderately long, slightly curved, approximately orthocline. Teeth small, delthyrial cavity deep; dental plates short; umbonal cavities mostly filled; muscle field with a short thickening anterior to its front margin; diductor scars slender; adductor track wide.

Measurements in mm.—Holotype, length 15.2, width 18.2, hinge width 21.4, thickness 4.1.

Type.—Holotype: 109797.

Horizon and locality.—Probably Arline formation in Tennessee: James Wayland Farm near Riverdale, 9 miles east of Knoxville, Shooks Gap (T.V.A. 147-NE) Quadrangle.

Discussion.—This is a large species suggestive of *O. buttsi* but differs from that species in its stronger costae and much larger size.

ORTHAMBONITES BELLUS Cooper, new species

Plate 35, D, figures 35-51

Shell small for the genus, slightly wider than long, hinge slightly narrower than the greatest shell width which is at the middle. Cardinal extremities approximating a right angle. Lateral margins nearly straight; anterior margin narrowly rounded. Surface marked by narrowly rounded costellae separated by interspaces slightly narrower than the costellae. Intercalated costae occur, but intercalation takes place only in 1 generation on the umbo or in its vicinity; 30 to 32 costae at the anterior margin.

Pedicle valve with umbo and posteromedian portion swollen, beak prominent and with part of the umbo protruding posterior to the posterior margin. Anterior slope moderately steep, lateral slopes moderately steep but more so than the anterior one. Interarea moderately long, strongly curved, apsacline. Lateral profile moderately strongly convex and with the greatest curvature in the posterior half.

Pedicle interior with moderately strong teeth and thick dental plates that converge slightly toward the floor of the valve. Crural fossettes narrow but deep. Muscle area confined to the delthyrial cavity. Posterior portion of pallial trunks poorly defined.

Brachial valve gently convex in lateral profile, very broadly convex in anterior profile. Umbonal region moderately swollen. Sulcus originating less than a millimeter anterior to the beak, narrow and shallow, not reaching the anterior margin in adult shells. Flanks bounding the sulcus moderately convex with long gentle posterolateral slopes to the posterolateral extremities which are somewhat flattened.

Brachial interior with moderately long brachiophores, supported by shell substance deposited along their lower edge. Sockets moderately deep. Notothyrial platform swollen in adults; cardinal process simple, thickest anteriorly and tapering posteriorly to a thin septum. Muscle field indistinct.

Measurements in mm.—

| | | Length | Width | Hinge width | Thickness |
|----------|------------------------------------|--------|-------|-------------|-----------|
| Paratype | (pedicle valve 116866b) | 9.7 | 10.6 | 9.6 | ? |
| " | (" " 116866a) | 8.9 | 10.1 | 9.9 | ? |
| " | (brachial valve 116866d) | 9.6 | 11.8 | 10.3 | ? |
| " | (" " 116866f) | 9.6 | 11.7 | 10.6 | ? |
| " | (both valves 116866g) | 10.2 | 10.6 | 10.1 | 4.5 |

Types.—Holotype: 116866c; figured paratypes: 109799a-e, 116866a,e,f; unfigured paratypes: 116866b,d,g.

Horizon and locality.—Chatham Hill formation in Virginia: On the Grayson Farm, 4 miles southwest of Bland, Bland County; north slope of Walker Mountain, 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—This species has some of the external expression of *O. rotundiformis* but differs in having less costae, lesser convexity of the pedicle valve, somewhat more convex brachial valve, and a more strongly apsacline interarea. This species is common in the lower Chatham Hill near Sharon Springs.

ORTHAMBONITES BIELSTEINI Cooper, new species

Plate 36, B, figures 9-18

Shell of about medium size for the genus, longitudinally semielliptical in outline; length and width equal, or wider than long. Hinge slightly narrower than the greatest shell width which is at about the middle. Lateral margins gently rounded; anterior margin somewhat narrowly rounded. Surface costate, costae 15 to 18 in number, subangular and with interspaces narrower than the width of the costae.

Pedicle valve unevenly convex in lateral profile with the greatest convexity in the posterior half, the front half somewhat flattened. Anterior profile with narrowly rounded summit and steeply sloping sides. Umbo subcarinate and preumbonal region swollen and produced anteriorly as a low fold which becomes nearly obsolete at the front margin. Flanks flat in profile with moderately steep slopes. Anterior slope not so steep as the lateral ones. Interarea short, curved, gently apsacline.

Brachial valve with gently convex lateral profile but with the greatest curvature in the umbonal region. Anterior profile a slightly convex arch slightly depressed medially. Sulcus originating on the umbo, expanding anteriorly, shallow throughout its extent and occupying about 4 mm. at the front of the valve. Flanks very gently convex. Cardinal extremities depressed noticeably. Interarea short, anacline.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------|--------|-------|-------------|-----------|
| Holotype | 11.5 | 11.8 | 9.3 | 5.6 |
| Figured specimen (109801) | 10.9 | 12.1 | 10.0 | ? |

Types.—Holotype: 109803a; figured paratype: 109803b; unfigured paratypes: 109803c,d; figured specimens: 109845a, 109801.

Horizon and locality.—Martinsburg formation (Salona equivalent) in Virginia: About 14 miles north of Staunton.

Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Benbolt formation in Virginia: $\frac{1}{4}$ mile east of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

Shippensburg formation in Pennsylvania: Railroad cut 1.7 miles southwest of Marion, Chambersburg (15') Quadrangle.

Shippensburg formation (Pinesburg member—shaly beds between *Echino-sphaerites* and lower *Nidulites* zones) in Maryland: On U. S. Highway 40, just west of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—*Orthambonites bielsteini* most nearly resembles *O. buttsi* Schuchert and Cooper and *O. mostellerensis*, new species. From the former it differs in its less transverse outline and less prominent median sulcus on the brachial valve. From the latter *O. bielsteini* differs in having less numerous and more narrowly elevated costae.

ORTHAMBONITES BIFURCATUS Cooper, new species

Plate 34, A, figures 1-6

Shell of about medium size for the genus, wider than long with the hinge considerably narrower than the greatest shell width which is at the middle. Cardinal extremities obtuse. Sides fairly strongly rounded; anterior margin broadly rounded. Surface marked by narrow, elevated, subangular costae that bifurcate at various distances from the beak. Including bifurcations, about 60 costae occur along the anterior margin.

Pedicle valve with lateral profile moderately convex and with the greatest curvature in the posterior half. Anterior profile moderately convex with long and moderately steep slopes. Posterior margins curving away from the beak which protrudes conspicuously. Umbo swollen and continued anteriorly as a low fold to the front margin. Lateral areas sloping gently to the margins, the slopes steepening to the umbonal slopes which are short and abrupt. Interarea short, curved, apsacline.

Brachial valve less deep than the pedicle valve, gently convex in both profiles. Median sulcus originating at the umbo and extending to the anterior margin, deepening and widening anteriorly to occupy about one-third the width at the anterior margin. Flanks gently swollen with short concave and steep lateral slopes. Posterolateral extremities flattened. Interarea short.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------|--------|-------|-------------|-----------|
| Holotype | 11.7 | 14.6 | 10.4 | 5.7 |
| Paratype (109798g) | 10.0 | 12.3 | 9.2 | 5.0 |
| “ (109798d) | 9.6 | 12.3 | 8.9 | 4.4 |

Types.—Holotype: 109798e; figured paratype: 109798g, 116869; unfigured paratypes: 109798a-d,f,h,i.

Horizon and locality.—Upper Pogonip group (*Rhysostrophia* zone) in Nevada: North side of Ikes Canyon about 1 mile above the entrance, east side of Toquima Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by the strong bifurcation of the costae, a feature that will distinguish it from most members of the genus. It differs

from *O. divaricatus* in having a shallower brachial sulcus, narrower and more elevated costae, and more numerous bifurcations of the costae.

The interior of a pedicle valve is revealed in one specimen and shows a short and narrow delthyrial cavity with the usual orthoid musculature, but a low ridge extends anteriorly nearly to the middle of the valve. This ridge is much longer than the one in *O. divaricatus*.

ORTHAMBONITES BLOUNTENSIS Cooper, new species

Plate 35, C, figures 26-34

Hebertella ? sp. BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, pl. 73, figs. 31-33, 1942.

Shell small for the genus, wider than long; hinge forming the greatest width of the valves. Cardinal extremities slightly acute. Lateral margins gently curved and sloping slightly medially. Anterior margin broadly rounded. Anterior commissure slightly sulcate. Ornamentation consisting of 17 or 18 broadly subangular costae.

Pedicle valve moderately convex with the greatest convexity in the swollen umbonal region. In anterior profile the convexity is moderate. Lateral slopes flat and moderately steep. Interarea curved, slightly apsacline. Beak incurved. Muscle area confined; median ridge thick and short. Interior with stout teeth, deep fossettes, and thick, short dental plates. Adductor track thickened.

Brachial valve gently convex in lateral profile; median sulcus narrow, occupying one-third the width. Sulcus occupied by two costae. Flanks bounding sulcus gently swollen. Cardinal extremities depressed; slopes to extremities gentle, concave. Beak inconspicuous; interarea moderately long. Interior having a narrow notothyrial cavity, simple cardinal process and stout brachiophores.

Measurements in mm.—Holotype, length 7.8, dorsal length 6.6, width 9.1, hinge width 9.8, thickness 4.5.

Types.—Holotype: 109812h; figured paratypes: 109812a-c; unfigured paratypes: 109812d-g,i,j.

Horizon and locality.—Arline formation in Tennessee: North side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville; 100 yards southwest of Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Arline formation in Virginia: In the quarry just north of Marion, Marion (T.V.A. 218-SE) Quadrangle.

Discussion.—This species is approximately intermediate between *O. buttsi* and *O. bielsteini*. The former is larger and wider and with more distant costae. In size and form *O. bielsteini* is somewhat larger but is more elongate and has a deeper and wider sulcus on the brachial valve. It differs from *O. rotundiformis* in its greater width and less prominent internal markings.

ORTHAMBONITES BRACHIOPHORUS Cooper, new species

Plate 36, E, figures 32-39

Shell large, suggesting a *Dinorthis* in appearance, wider than long with obtuse or right angular cardinal extremities. Hinge as wide as the width at the middle or

slightly less. Lateral margins gently rounded; anterior margin broadly rounded. Anterior commissure rectimarginate. Surface marked by 30 to 32 strong, broadly rounded costae having interspaces about the same width as the costae. Interspaces marked by fine radial costellae and strong concentric fila, the latter best developed on the median and posterior parts but the radial costellae best shown along the anterior parts.

Pedicle valve moderately convex in lateral profile with the most convex portion located in the posterior half, front half flattened. Anterior profile with flattened sides and narrowly rounded crest at the middle; beak prominent forming an angle of 153° . Median region moderately swollen with moderately steep slopes to the posterolateral extremities, the slopes becoming less steep anteriorly; anterior slope long and gentle. Interarea moderately long, apsacline. Muscle area small and narrow for such a large valve occupying less than a third the length. Dental plates short and receding; pallial impression indistinct.

Brachial valve slightly convex in anterior and lateral profile; sulcus originating at the posterior margin, narrow and shallow and extending to about the middle of the valve where it is lost in the general convexity of the surface. Flanks slightly swollen; cardinal extremities flattened. Interior with narrow and short but moderately deep notothyrial cavity; cardinal process a thin septum; brachio-phores long and slender; median ridge stout, reaching to the middle. Pallial impressions indistinct.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|------------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 20.7 | 24.5 | 20.7 | 5.7 |
| Paratype (109835b) | 16.2 | 20.0 | 19.5 | 2.0 |

Types.—Holotype: 109835c; figured paratypes: 109835a,b,d,f; unfigured paratype: 109835e.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: Opposite road intersection with Hays Creek, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle; road to Smyth Gap, 3 miles southwest of Clinchburg, Glade Spring (T.V.A. 212-SE) Quadrangle.

Discussion.—This species can be recognized by its large size and the strong concentric ornamentation between the costae. Specimens from the locality 2 miles northwest of Brownsburg measure over 30 mm. in width and about 25 mm. in length. This is one of the largest members of the genus so far found in this country. This species has some features of *Hesperorthis* as, for example, the long slender brachio-phores and the transverse form of the pedicle valve. The few specimens showing the delthyrium have no trace of a pseudodeltidium but traces of lateral (deltidial?) plates are present. The size and ornamentation will distinguish this species from all others herein described (see *O. neumani*).

ORTHAMBONITES BUTTSI (Schuchert and Cooper)

Plate 36, D, figures 21-31

Orthis crasicosta BUTTS (not Pander 1830), Geol. Surv. Alabama, Special Rep. 14, p. 114, 116, pl. 26, figs. 14-15, 1926.

Orthis buttsi SCHUCHERT and COOPER, Mem. Peabody Mus. Nat Hist., vol. 4, pt. 1, p. 75, footnote, 1932.

Shell of medium size, wider than long and with the hinge forming the greatest width or slightly narrower. Lateral margins gently curved and sloping medially; anterior margin broadly curved. Anterior commissure very gently sulcate. Costae direct, strong, subangular, numbering 19 on the pedicle valve. Entire surface covered by fine radial threads.

Pedicle valve moderately convex in both profiles. Greatest convexity located in the posterior half; the median costa a little elevated and forming the center of a low fold that extends from the beak to the anterior margin. Flanks flattened; slopes to lateral margins gentle. Interarea curved, moderately apsacline; beak incurved. Interior with deep but short delthyrial cavity; nearly obsolete dental plates, short median thickening anterior to muscle area.

Brachial valve slightly convex in lateral profile, nearly flat and slightly depressed in the middle in anterior profile. Sulcus shallow and narrow, occupied by 2 costae, occupying about one-quarter the width at the anterior margin. Interarea short; beak inconspicuous. Flanks bounding sulcus slightly swollen with concave slopes to the cardinal extremities. Interior with low median ridge not meeting the center, moderately stout brachiophores supported by shell deposited in notothyrial cavity. Cardinal process a simple ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.4 | 10.2 | 13.7 | 12.4 | 5.4 |
| Hypotype (109808a) | 12.0 | 10.4 | 14.6 | 13.5 | 5.2 |

Types.—Holotype: 71497; figured hypotypes: 109808a, 116870a-c; unfigured hypotypes: 109808b,c, 116870d-f.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile north of Pelham; on west side of U. S. Highway 31, $\frac{1}{3}$ mile N. 10° E. of Pelham Station, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 20 S., R. 3 W., all on Bessemer Iron District (15') Quadrangle; cut on L. and N. RR., $\frac{3}{4}$ mile northwest of Mosteller, Columbiana (15') Quadrangle: intersection Bailey Gap road with main road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., $1\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Discussion.—The closest species to this one is *O. angulatus* from the Arline formation at Riverdale, near Knoxville, Tenn. This species differs from *O. buttsi* in its larger size, more numerous angular costae and stronger fold on the pedicle valve.

ORTHAMBONITES DINORTHOIDES Cooper, new species

Plate 33, E, figures 20-27

Shell of moderate size, wider than long, with the length equal to about two-thirds the width. Hinge slightly narrower than the greatest shell width which is located near the middle. Cardinal extremities obtusely angular. Lateral margins gently rounded; anterior margin broadly rounded. Anterior commissure slightly sulcate. Surface costate with the number of costae varying from 21 to 25. Costae narrowly rounded and with interspaces wider than the ribs. Interspaces marked by fine radial and concentric lines.

Pedicle valve very gently convex in lateral profile with greatest convexity located at the umbo; anterior profile moderately convex. Beak well defined, projecting a little posterior to the posterior margin, obtuse, umbo narrowly swollen. An ill-defined fold formed at the umbo by the central 3 costae. Fold best defined in the posterior half but flattened at the front where there may be a shallow depression in its place.

Brachial valve gently convex in lateral profile; gently convex in anterior profile and with the center sulcate. Sulcus narrow and shallow and containing 2 costae. Sulcus originating at the umbo and extending to the front margin. Flanks of shell gently convex bounding the sulcus. Slopes to cardinal extremities gentle; posterolateral extremities flattened.

Interiors.—Muscle area of pedicle valve more elongate than usual in the genus and with a truncate anterior. Diductor scars elongate but adjustor scars small and inconspicuous. Cardinal process with short shaft and narrow myophore.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 13.2 | 17.5 | 16.8 | 2.5 ? |
| Paratype (brachial valve 109821a) ... | 15.6 | 21.0 | 15.0 ? | 1.75 ? |

Types.—Holotype: 109823b; figured paratypes: 109821a,d, 109822a,b, 109823a,c,d; unfigured paratypes: 109821b,c,e,f, 109822c-h, 109823e-h.

Horizon and locality.—Oil Creek formation in Oklahoma: Sec. 14, T. 2 S., R. 1 E., about 5 miles north-northwest of Springer, Murray County; 3 miles east of Pooleville, Murray County; 614 feet above the base on west side U. S. Highway 77, NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., vicinity of Springer, Carter County.

Discussion.—As the name of this species implies, it is quite similar to the genus *Dinorthis*. The dinorthoid features are in the interior rather than on the exterior. The elongate diductor scars which flare a little laterally at their extremities, and the truncate front of the muscle field are most suggestive of *Dinorthis*. Similarities to this genus also occur in the brachial valve. The cardinal process with a well-defined myophore suggests *Dinorthis*, but its form and shaft are more like that of *Orthambonites*. Although the muscle field, like the cardinal process, suggests *Dinorthis*, the small development of the adjustor scars and fine radial ornament suggest *Orthambonites* rather than *Dinorthis*.

Orthambonites dinorthoides reminds one of *O. paucicostata* Ulrich and Cooper

from the Upper Pogonip of Nevada but differs in having wider valves with narrower and less distantly spaced costae.

ORTHAMBONITES DIVARICATUS Cooper, new species

Plate 33, A, figures 1-3

Shell of about the usual size for the genus, valves unequally convex, length equal to four-fifths of the width; hinge slightly narrower than the greatest shell width which is located slightly anterior to the middle. Cardinal extremities slightly obtuse. Anterolateral margins somewhat narrowly rounded, anterior margin broadly rounded. Anterior commissure slightly sulcate. Surface marked by strong subangular costae on the center and flanks, a generation of finer costae intercalated between the larger ones on the flanks and posterolateral extremities. Spaces between the costae ornamented by low, rounded fila, about 5 to the millimeter near the middle.

Pedicle valve moderately convex with the maximum convexity near the middle; anterior profile broadly convex. Beak small, incurved, protruding beyond the posterior margin. Median portion of valve forming an ill-defined fold and bearing the 3 largest costae. Flanks gently convex in anterior profile; anterolateral slopes gentle but the posterolateral slopes moderately steep. Interarea only slightly curved, apsacline. Delthyrium open. Dental plates short, receding; adductor field with small ridge extending anteriorly from thickened anterior end.

Brachial valve gently convex in both profiles; sulcus originating less than a millimeter anterior to the beak, shallow, widening anteriorly but occupying only about one-quarter of the width. Flanks gently convex with short gentle slopes to the cardinal extremities. Posterolateral extremities slightly flattened. Notothyrial cavity shallow, median ridge short, cardinal process not developed.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 12.7 | 15.3 | 12.8 | 4.2 |
| Paratype (brachial valve 109838b) ... | 7.8 | 11.4 | 8.9 | ? |
| " (" " 109838c) ... | 9.2 | 12.4 | 9.9 | ? |

Types.—Holotype: 109838a; figured paratype: 109838b; unfigured paratypes: 109838c-e.

Horizon and locality.—Effna-Rich Valley formations, in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species is characterized by the strong intercalation of costae between the primary ones and in this respect is unlike any other member of the genus from Virginia described in this paper. Some resemblance exists between this species and *O. mycale* Billings, but in the latter the muscular area of the pedicle valve is smaller and the fold of the brachial valve and sulcus of the pedicle valve are pronounced.

ORTHAMBONITES EUCHARIS (Ulrich and Cooper)

Orthis eucharis ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 99, pl. 14, E, figs. 15-18; pl. 57, B, figs. 10-12, 14-16, 1938.

Types.—Lectotype: 95875c; paratypes: 95875a,b,d-h.

Horizon and locality.—Upper Pogonip group (mottled zone 700 feet below the Eureka quartzite) in Nevada: Ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

ORTHAMBONITES ? EXFOLIATUS (Raymond)

Hebertella exfoliata RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 370, 1905.

Plectorthis exfoliata (Raymond), Ann. Carnegie Mus., vol. 7, No. 2, p. 238, pl. 35, figs. 11, 12, 1911.

Orthis costalis HALL, Pal. New York, vol. 1, pl. 4, bis, fig. 4b, 1847.

The description and figures of this small orthid have never permitted accurate understanding of the species, and this is true of the specimens available to the writer. The specific name is aptly chosen because all the specimens available have been broken from a somewhat dirty limestone and are much exfoliated, thus not permitting an understanding of the true nature of the exterior. The interior hitherto has never been described, except for the pedicle muscles.

A few specimens in sandy or silty matrix were subjected to treatment by acid and the shell dissolved away from the matrix. The pedicle valves reveal strong dental plates and a somewhat elongate muscle field having prominent diductor scars.

The brachial valve cardinalia consist of a prominent but low notothyrial platform having a prominent cardinal process thickened anteriorly. Brachiophores are short and thick. It is difficult to tell, from the specimens available, if plates support the brachiophores and are recumbent on the floor of the valve or if the notothyrial platform is that common to the Orthidae. The structures lie too close to the valve floor to be assigned to *Plectorthis*. The writer therefore tentatively assigns the species to *Orthambonites* even though the interior is atypical and the exterior suggests *Desmorthis*.

Horizon and locality.—Day Point formation, vicinity of Chazy, Rouses Point (15') Quadrangle; 3 miles north of Plattsburg and Valcour Island, Plattsburg (15') Quadrangle.

ORTHAMBONITES FRIENDSVILLENSIS Cooper, new species

Plate 36, A, figures 1-8

Shell of medium size for the genus, strongly inequivalved, the pedicle valve having the greater depth. Outline subquadrate; length and width nearly equal. Lateral margins straight or slightly concave; anterior margin broadly rounded. Cardinal extremities a right angle. Anterior commissure rectimarginate to sulcate. Surface marked by narrow, rounded costae separated by spaces narrower than the costae. Costae ranging in number from 32 to 36, and with from 6 to 8 occupying a space of 5 mm. at the front.

Pedicle valve moderately convex in lateral profile but more strongly convex in anterior profile. Greatest convexity posterior to the middle. Umbo and postmedian region swollen; anterior half gently convex and sloping moderately steeply to the anterior margin. Slopes to the cardinal extremities gently concave, moderately steep. Interarea strongly curved; beak incurved and overhanging the delthyrium. Lateral plates well developed. Interior with short receding dental plates, subcordate muscular area. Vascula media extending medially from diductors, then becoming subparallel.

Brachial valve gently and evenly convex in lateral profile; gently concave in anterior profile. Sulcus shallow and wide, shallowest at the front margin. Flanks of shell slightly swollen; anterolateral areas depressed. Cardinal extremities deflected slightly dorsally. Interarea short; beak inconspicuous. Interior with long brachioophores, short median ridge, simple cardinal process and wide adductor field.

Measurements in mm.—

| | Length | Dorsal length | Width | Hinge width | Thickness |
|-----------------------|--------|---------------|-------|-------------|-----------|
| Holotype | 10.7 | 9.0 | 11.6 | 10.0 | 5.5 |
| Paratype (109827c) .. | 8.5 | 7.5 | 9.5 | 7.5 | 4.6 |
| " (109827g) .. | 11.3 | 9.8 | 11.2 | 9.4 | 5.8 |

Types.—Holotype: 109827b; figured paratypes: 109827c,g,h; unfigured paratypes: 109827a,d-f,i-p.

Horizon and locality.—Arline formation in Tennessee: North side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville; 100 yards southwest of Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 1,500 feet south of the mouth of Burnett Creek, Shooks Gap (T.V.A. 147-NE) Quadrangle.

Discussion.—This species is characterized by its subquadrate form and the fine, closely spaced costae. It resembles *O. bellus* but differs in having more finely costate ornamentation.

ORTHAMBONITES MICHAELIS (Clark)

Orthis michaelis CLARK, Journ. Paleont., vol. 9, No. 3, p. 242, pl. 24, figs. 5, 6, 1935.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 101, pl. 14C, figs. 11, 12, 21, 23, 25-29, 1938.

Types.—Hypotypes: 91316a,b, 91318a,b; 91320a-d.

Horizon and locality.—Swan Peak formation in Utah; Kanosh formation in Utah.

ORTHAMBONITES MINUS Cooper, new species

Plate 34, D, figures 16-20

Shell small, wider than long, somewhat rectangular in outline; hinge slightly less than the greatest shell width which is at the middle; sides gently rounded; anterolateral extremities narrowly rounded; anterior margin nearly straight; anterior commissure sulcate; surface marked by 35 to 36 narrowly rounded and elevated costae separated by spaces slightly less than the width of the costae.

Pedicle valve gently convex in lateral profile; greatest convexity located in the posterior half; anterior profile broadly convex, somewhat sharply pointed in the middle but with long, gently descending slopes; umbo gently swollen; anterior to umbo a narrow fold consisting of 5 costae extends to the anterior margin; flanks bounding fold gently swollen.

Brachial valve very gently convex in lateral profile with the greatest convexity in the posterior half; anterior profile broadly convex and indented medially; sulcus originating at the umbo and extending to the anterior margin where it occupies about one-third the width. Flanks bounding sulcus somewhat swollen; posterolateral extremities flattened; umbonal slopes short and gentle.

Measurements in mm.—Holotype, length 4.5, brachial length 4.1, width 5.5, hinge width 4.7, thickness 2.2.

Type.—Holotype: 116882.

Horizon and locality.—Tulip Creek formation (about 90 feet below top) in Oklahoma: On east edge of sec. 25, T. 2 S., R. 1 E., east side of U. S. Highway 77, 2½ miles north of Springer, Carter County.

Discussion.—This species is similar to *O. minutus* in size but differs in having more distantly spaced and fewer costae, a deeper sulcus and different proportions.

ORTHAMBONITES MINUSCULUS (Phleger)

Orthis minusculus PHLEGER, S. California Acad. Sci., Bull., vol. 32, pt. 1, p. 7, pl. 2, figs. 6, 7 (reprint), 1933.

Orthis minuscula Phleger, ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 101, pl. 15D, figs. 22-25, 1938.

Types.—Hypotypes: 91310a-d.

Horizon and locality.—Mazourka formation, Inyo Mountains, Calif. Upper Pogonip group (sponge beds), Ikes Canyon, Toquima Range, Roberts Mountains (1°) Quadrangle, Nevada.

ORTHAMBONITES MINUTUS Cooper, new species

Plate 42, A, figures 1-9

Shell minute, wider than long with hinge about equal to the midwidth or slightly wider or narrower; sides gently rounded; anterior margin broadly rounded; surface marked by upward of 40 closely crowded, narrowly rounded costae.

Pedicle valve gently convex in lateral profile with the greatest convexity at about the middle; anterior profile broadly convex and with long lateral slopes. Median region from umbo to anterior margin somewhat swollen to form an indistinct fold; interarea moderately long, strongly apsacline; teeth large; dental plates small, receding, and bounding a broad and fairly deep delthyrial cavity. Individual muscle scars not preserved.

Brachial valve with a gently convex lateral profile and a lobate anterior profile; sulcus originating on the umbo, widening to the anterior margin where it occupies nearly half the shell width; flanks bounding sulcus moderately swollen;

cardinal process a thin ridge; median ridge formed by inner swelling produced by sulcus; notothyrial platform low; brachiophores short.

Measurements in mm.—

| | | Length | Brachial length | Width | Hinge width | Thickness |
|----------|------------------------------|--------|-----------------|-------|-------------|-----------|
| Paratype | (pedicle valve 116883f)..... | 3.1 | ? | 5.2 | 5.0 | 0.9 |
| " | (" " 116883b).... | 2.6 | ? | 3.2 | 3.0 | 0.6 |
| " | (brachial valve 116883g).... | ? | 3.5 | 5.2 | 5.1 | 0.7 |
| " | (" " 116883d).... | ? | 2.6 | 3.6 | 3.4 | 0.4 |

Types.—Holotype: 116883c; figured paratypes: 116883a,b,d,e; unfigured paratypes: 116883f-h.

Horizon and locality.—McLish formation (bed 45) in Oklahoma: On West Spring Creek, sec. 6, T. 2 S., R. 1 W., Murray County.

Discussion.—For differences between this species and *O. minus* Cooper, see *O. minus*.

ORTHAMBONITES MOSTELLERENSIS Cooper, new species

Plate 35, A, figures 1-10

Shell of medium size for the genus, subquadrate in outline, width slightly greater than length. Lateral margins nearly straight; anterolateral extremities broadly rounded; anterior margin truncate. Cardinal extremities a right angle. Anterior commissure sulcate. Surface marked by about 15 broadly angular costae.

Pedicle valve moderately convex with the greatest convexity posterior to the middle. Median fold obscure, defined only in the anterior three-quarters. Lateral slopes steep, gently concave. Interarea long, strongly incurved; beak incurved. Teeth large; fossettes deep. Dental plates short; umbonal cavities filled by callus. Muscle area small, slightly thickened.

Brachial valve slightly convex with a poorly defined median sulcus originating at the umbo and extending to the anterior margin where it occupies slightly more than one-third the width. Sulcus occupied by 2 costae. Interior with short brachiophores partly engulfed by callus. Notothyrial platform thickened; cardinal process stout.

Measurements in mm.—Holotype, length 11.5, dorsal length 10.0, width 12.3, hinge width 10.0, thickness 5.0.

Types.—Holotype: 109810b; figured paratypes: 109810a,c,e; unfigured paratypes: 109810d,f,g.

Horizon and locality.—Little Oak formation in Alabama: Cut on L. and N. RR., $\frac{3}{4}$ mile northwest of Mosteller, Columbiana (15') Quadrangle.

Discussion.—This species is characterized by its broadly angular costae and its subquadrate outline. It is similar to *O. rotundiformis* but differs in its somewhat larger size and the broader costae and more quadrate outline. It differs from *O. blountensis* in size and shape. It is about the same size as *O. bielsteini* but the costation is coarser. It is readily distinguishable from its associate in the Little Oak limestone, *O. buttsi*, by its more quadrate form and more distant and broadly angular costae.

ORTHAMBONITES MULTICOSTELLATUS Cooper, new species

Plate 33, B, figures 4-7

Shell of about medium size for the genus, wider than long and with gently convex sides and strongly rounded anterior margin. Cardinal extremities approximately a right angle or slightly obtuse. Hinge equal to or slightly less than the width at the middle. Surface marked by about 36 narrowly rounded and closely spaced costae.

Pedicle valve gently convex in lateral profile and with the greatest convexity in the umbonal region. Anterior profile swollen strongly in the middle and narrowly rounded; lateral slopes flat and steep. Umbonal slopes steep and concave; umbo swollen and median portion inflated. Beak strongly incurved; interarea curved, apsacline. Teeth small.

Brachial valve evenly and moderately convex in lateral profile; greatest convexity in the median region. Anterior profile evenly and broadly convex; umbonal region sulcate, sulcus small and disappearing in the general convexity of the valve near the middle. Median region swollen. Median ridge short; brachioophores short and stout; cardinal process a simple ridge. Notothyrial platform thickened.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|--------|-----------|
| Holotype (pedicle valve) | 10.9 | 13.7 | 4.4 |
| Paratype (brachial valve 116875a) | 14.4 | 15.6 ? | 3.4 |
| “ (“ “ 116875b) | 10.9 | 14.2 | 2.7 |

Types.—Holotype: 116876a; figured paratypes: 116875a; unfigured paratypes: 116875b-d, 116876b.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Virginia: Along the railroad about $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Oranda formation in Virginia: Along railroad $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species is characterized by its narrow and numerous costae and in this respect differs from all other Virginia species of *Orthambonites* described herein.

ORTHAMBONITES NEUMANI Cooper, new species

Plate 37, D, figures 15-28

Shell large, rectangular in outline with the length equal to about four-fifths the width at the middle; cardinal extremities acute; sides slightly concave anterior to the cardinal extremities; anterior margin broadly rounded; valves subequally convex; anterior commissure rectimarginate. Surface costate, costae rounded and separated by spaces of equal width to the costae, about 32 costae along the margin. Entire surface covered by fine concentric fila.

Pedicle valve evenly and gently convex in lateral profile; anterior profile broadly and gently convex. Interarea moderately long, apsacline; beak small.

Umbo gently swollen, the swelling continuing anterior to the front margin as a broad, poorly defined fold. Lateral slopes long and gentle; umbonal slopes fairly steep. Pedicle interior with short, stout dental plates, small teeth, and subquadrate muscle field. Pallial marks not preserved.

Brachial valve gently convex in lateral profile, broadly convex in anterior profile, but with the median region sulcate and the sides appearing as two low swellings. Umbo gently swollen; sulcus originating on the umbo, extending anteriorly to the front margin. Sulcus narrow throughout, deepest in the median region and becoming broad and shallow at the anterior margin. Flanks gently swollen with short, steep slopes to the sulcus but long and gentle slopes to the margins. Brachial interior with small shallow notothyrial cavity, thick notothyrial platform, short brachiophores, short median ridge and simple cardinal process stoutest at the anterior end.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 18.9 | ? | 25.6 | 27.4 | ? |
| Paratype (pedicle valve 116874a)... | 17.6 | ? | 25.8 | 29.0 | 4.0 |
| " (" " 116874c)... | 17.1 | ? | 23.4 | 25.4 | 4.1 |
| " (brachial valve 116874d)... | ? | 20.8 | 26.6 | 28.4 | 2.6 |
| " (" " 116874-1) . | ? | 17.7 | 19.7 | 23.4 | 2.3 ? |

Types.—Holotype: 116874e; figured paratypes: 116874b,d,h,l,n,o,q; unfigured paratypes: 116874a,c,f,g,i-k,m,p.

Horizon and locality.—Tellico formation (sandstone No. 3 of Neuman) in Tennessee: 0.3 mile northwest of Cold Springs School, Wildwood (T.V.A. 147-SE) Quadrangle.

Discussion.—This is one of the largest *Orthambonites* so far seen in the Ordovician of the Appalachians. It is characterized by its squarish muscle area in the pedicle valve, the short brachiophores and the strong costae. It strongly resembles *Dinorthis* and may be mistaken for that genus. The strongly convex pedicle valve, however, should eliminate the confusion. Of described species *O. neumani* is most like *O. dinorthoides*. It differs in having more numerous costae, larger size, and a squarer muscle field in the pedicle valve. This species differs from *O. brachiophorus*, which it externally resembles, in having much shorter brachiophores and a squarish muscle field in the pedicle valve.

ORTHAMBONITES OCCIDENTALIS Cooper, new species

Plate 34, B, figures 7-9

Shell of about medium size for the genus, the length about five-sixths the width. Hinge slightly narrower than the greatest shell width which is at about the middle. Cardinal extremities slightly obtuse. Sides slightly rounded; anterior margin broadly rounded. Surface marked by 27 elevated, narrowly rounded, slender costae separated by spaces about equal to the costae in width.

Pedicle valve moderately convex in lateral profile with the greatest convexity at about the middle; anterior profile strongly convex with broadly rounded crest

and steeply sloping sides. Median region inflated; anterior slope long and steep. Posterolateral areas somewhat swollen and without steep slopes. Posterior margins forming an angle of 120° with the beak. Interarea moderately long, slightly curved, apsacline. Delthyrium narrow, open.

Brachial valve gently and evenly convex in anterior and lateral profiles. Sulcus shallow, narrow, originating at the umbo and extending to the front margin where it occupies less than a quarter of the width. Sulcus occupied by 4 costae. Flanks gently convex. Umbonal region slightly swollen and with short but steep umbonal slopes. Posterolateral areas slightly flattened. Interarea very short.

Measurements in mm.—Holotype, length 15.5+, brachial length 13.0, width 18.0, hinge width 16.0, thickness 8.6.

Types.—Holotype: 109807a; unfigured paratype: 109807b.

Horizon and locality.—Upper Pogonip group (*Rhysostrophia* zone) in Nevada: North side Ikes Canyon about 1 mile above the entrance, Toquima Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is larger and more numerously costated than *O. minusculus* and is distinguished from *O. michaelis* by its smaller, narrower, and more distantly spaced costae, and the somewhat more transverse outline.

ORTHAMBONITES PARVICRASSICOSTATUS Cooper, new species

Plate 35, B, figures 11-25

Shell small, slightly wider than long, lateral margins gently rounded to nearly straight, anterior margin narrowly rounded. Cardinal extremities obtuse or produced into minute ears. Anterior commissure sulcate. Hinge slightly wider or slightly narrower than the shell width at the middle. Surface marked by 16 to 18 angular costae that widen anteriorly. Interspaces about equal to the width of the costae, crossed by fine concentric fila.

Pedicle valve with lateral profile gently convex and with the greatest convexity at about the middle. Umbo strongly convex. Anterior profile strongly humped in the median region with the flanks descending moderately steeply to the lateral margins. Median region of 5 largest costae somewhat elevated to produce a fold. Interarea short, beak strongly incurved.

Brachial valve gently convex with the greatest convexity in the region posterior to the middle. Beak small, umbo small, smooth, short. Sulcus originating just anterior to the umbo, widening rapidly to occupy about half the width. Four costae occupy the sulcus. Flanks defined by a slight elevation of the 2 costae bounding the sulcus. Posterolateral extremities flattened.

Pedicle interior with small teeth, and short, stout dental plates. Muscle area slightly thickened, extending anterior to the anterior ends of the dental plates. Brachial interior with short, stout brachiophores supported by a moderately thickened notothyrial platform. Cardinal process thickened on the anterior face.

Measurements in mm.—

| | Length | Brachial length | Thickness | Width | Hinge width |
|-------------------------|--------|-----------------|-----------|-------|-------------|
| Holotype | 7.0 | 6.3 | 3.0 | 7.0 | 6.8 |
| Paratype (109832a)..... | 5.6 | 5.0 | 3.0 | 6.5 | 5.4 |
| " (116871b)..... | 7.5 | 6.7 | 4.0 | 7.5 | 6.9 |
| " (116872b)..... | 6.9 | 6.4 | 3.2 | 8.1 | 7.9 |
| " (109832g)..... | 5.0 | 4.8 | 3.0 | 5.8 | 5.2 |

Types.—Holotype: 116872a; figured paratypes: 109832a,b, 116871b, 116872b,c; unfigured paratypes: 109832c-j, 116871a.

Horizon and locality.—Benbolt formation in Virginia: Wash on east side slope in pasture, 0.2 mile south of middle fork of Moccasin Creek, 1½ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; west slope of the hill ½ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle.

Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: Opposite road intersection with Hays Creek, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle; south side of the road, 0.2 mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—This species is characterized by its small size, strong angular costae and nearly equal length and width. As now constituted this is a variable species. The specimens from Porterfield Quarry are a little more strongly convex than the Benbolt specimens, and the internal structures are more neatly defined. The Benbolt specimens on the other hand have very thick dental plates and a thickened callosity anterior to the muscle area of the pedicle valve. The exterior impressions from northwest of Brownsburg show the concentric fila well.

This species differs from *O. blountensis* in its more quadrate form and from *O. bielsteini* in its smaller size and quadrate form, although the number of costae is about the same for the two species.

ORTHAMBONITES PAUCICOSTATUS (Ulrich and Cooper)

Plate 33, D, figures 12-19

Orthis paucicostata ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 103, pl. 15, C, figs. 16-21, 1938.

Types.—Holotype: 92841; paratypes: 92842a-e; figured hypotypes; 109834a, b,m; unfigured hypotypes: 109834c-l.

Horizon and locality.—Upper Pogonip group (lower part of *Rhysostrophia* bed) in Nevada: Ikes Canyon, east side Toquima Range, Roberts Mountains (1°) Quadrangle.

ORTHAMBONITES RECTANGULATUS Cooper, new species

Plate 34, C, figures 10-15

Shell rectangular in outline with the hinge equal to or slightly wider than the shell at the middle; sides gently rounded; anterior margin broadly rounded;

biconvex, the pedicle valve with the greater convexity. Surface marked by strong angular costae numbering about 16 to 18.

Pedicle valve gently convex in lateral profile and with the maximum convexity in the midregion; anterior profile broadly convex but with the median region narrowly rounded and slightly elevated; umbo narrowly swollen, the swelling continued to the front margin as a poorly defined fold; lateral slopes flat and gently sloping; interarea short, curved, gently apsacline; beak incurved.

Brachial valve very gently convex with maximum convexity at the middle; anterior profile broadly convex but with a narrow, V-shaped depression in the middle; sulcus originating at the umbo widening anteriorly to the margin where it occupies slightly more than one-third the shell width; flanks bounding sulcus gently swollen; posterolateral extremities slightly depressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.0 | 7.5 | 9.6 | 9.4 | 4.0 |
| Paratype (109802a)..... | 6.5 | 6.0 | 7.9 | 8.1 | 3.5 |

Types.—Holotype: 116877; paratype 109802a.

Horizon and locality.—Shippensburg formation (Pinesburg member—just above *Echinosphaerites* zone) in Maryland: On U. S. Highway 40 at Wilson, west side Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—This species is similar to *O. blountensis* in shape but differs in having a less convex brachial valve, more elongate interarea, less convex pedicle umbo, and less swollen pedicle valve.

ORTHAMBONITES ROTUNDIFORMIS Cooper, new species

Plate 34, F, figures 27-39

Small to medium size for the genus, thick-shelled; length and width nearly equal or with the length exceeding the width. Lateral margins straight to slightly curved; anterior margin narrowly rounded. Hinge equal to or slightly less than the greatest shell width. Cardinal extremities slightly obtuse or forming a right angle. Surface marked by 18 to 24 low, subangular costae separated by spaces wider than the costae.

Pedicle valve with the maximum convexity in the posterior half when viewed from the side but in anterior profile strongly convex with slightly flattened flanks. Posterior margin forming an angle of 120°. Beak strongly incurved; umbo and median part swollen and convex with flattened but steep slopes to the lateral margins. Anterior slope less steep than the lateral ones. Interarea long, gently apsacline. Teeth large with deep fossettes; dental plates stout, short; umbonal cavities filled by callus. Muscle area confined to the delthyrial cavity.

Brachial valve strongly convex in lateral profile with the maximum curvature in the posterior half and with the front half flattened. Anterior profile strongly convex but with the crest of the curve slightly flattened. Sulcus poorly defined, originating at the umbo. Flanks swollen and with steep lateral slopes. Posterolateral

slopes steep. Interior with short stout brachiophores and much thickened notothyrial platform and cardinal process. Median ridge short and low.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-------|-------------|-----------|
| Holotype | 8.8 | 7.9 | 7.2 | 5.1 |
| Paratype (pedicle valve 109842a)... | 8.5 | 8.2 | 7.2 | ? |
| “ (“ “ 109840a)... | 8.6 | 8.7 | 8.0 | ? |
| “ (brachial valve 109840j) . | 9.8 | 10.1 | 9.6 | ? |
| “ (“ “ 109843b) . | 7.9 | 8.9 | 6.9 | ? |

Types.—Holotype: 109843a; figured paratypes: 109840f-j, 109842a,b, 109843b,c; unfigured paratypes: 109840a-e, 109843d-m.

Horizon and locality.—Athens formation (*Christiania* bed) in Tennessee: 600 feet S. 40° E. of the railroad crossing 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-NE) Quadrangle; roadside 2½ miles south-south-east of Riceville; 0.2 mile southeast of Britton Church, 2½ miles northeast of Charleston, Calhoun (T.V.A. 125-SW) Quadrangle; Cleveland-Benton road, 5 to 5½ miles east of Cleveland, near old Climer, East Cleveland (T.V.A. 120-NE) Quadrangle.

Discussion.—The species is characterized by the strong convexity of both valves, the brachial valve being unusually swollen for the genus. The distant costae and the elongate form are other distinctive characters. The species differs from *O. blountensis* in its elongate form and the more numerous and smaller costae. It differs from *O. friendsvillensis* in the more distant costae and the more convex brachial valve. It can be readily separated from *O. parvicrassicostatus* by its more inflated valves and somewhat more numerous costae.

ORTHAMBONITES SUBCONVEXUS Cooper, new species

Plate 34, E, figures 21-26

Shell of about medium size for the genus, wider than long, with rounded cardinal extremities and gently rounded lateral margins. Greatest width just posterior to the middle. Anterior margin broadly rounded. Anterior commissure rectimarginate. Ornamentation consisting of about 32 strongly elevated and narrowly rounded costae. No finer ornamentation except concentric fila preserved.

Pedicle valve gently convex in lateral profile and with the most convex part in the posterior third. Anterior profile very gently and broadly convex. Beak forming an angle of 140°. Umbonal and median regions gently swollen and descending to the anterior and lateral margins by gentle slopes, the anterior slope having the lesser steepness. Interarea strongly apsacline, only slightly curved.

Pedicle interior with dental plates nearly obsolete; teeth small and with small fossettes. Muscle field elongate with long and straight diductor scars and long, narrow adductor field slightly raised and separating the diductors. Vascula media divergent, indistinct.

Brachial interior with short and stout brachiophores supported by callus and the thickened notothyrial platform. Cardinal process simple, stout. Median ridge thick. Posterior adductor patches larger than the anterior ones.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--|--------|--------|-------------|-----------|
| Holotype (pedicle valve) | 13.5 | 16.4 | 12.5 | 3.5 |
| Paratype (brachial valve 109844b) | 13.0 | 15.5 ? | 13.4 | ? |

Types.—Holotype: 109844a; figured paratype: 109844b; unfigured paratypes: 109844c-e.

Horizon and locality.—Oil Creek formation in Oklahoma (75 to 100 feet below the top): On West Spring Creek, SW $\frac{1}{4}$ sec. 30, T. 1 S., R. 1 W., east of Pooleville, Murray County.

Discussion.—This species is most suggestive of *Orthis michaelis* that occurs in the Swan Peak formation of Utah. The Oklahoma species differs in the lesser convexity of both valves, the more inclined pedicle beak, the narrower pedicle muscle field and the more ponderous cardinalia and median ridge.

O. subconvexus has some of the features of *O. acutiplicatus* and *O. dinorthoides*. It differs from both in having more closely spaced costae and from *O. dinorthoides* in not having as elongate or such flaring pedicle muscles.

ORTHAMBONITES TENNESSEENSIS Cooper, new species

Plate 49, D, figures 16-21; plate 82, D, figures 13-20; plate 82, I, figure 40

Shell subquadrate in outline, hinge slightly narrower than the greatest shell width which is at the middle; sides gently curved; anterior margin narrowly rounded; biconvex, the pedicle valve having the greater depth. Surface marked by 18 strong, subangular costae.

Pedicle valve fairly strongly convex in lateral profile and with the greatest convexity in the median region; anterior profile somewhat narrowly convex; umbo narrow and protruding; median region swollen and with a somewhat indistinct narrow fold extending to the anterior margin; lateral slopes gently concave and fairly steep in the posterolateral region. Interarea narrowly curved, apsacline. Interior with short, thick dental plates; umbonal cavities filled; teeth small but with deep fossettes. Lateral plates slightly developed; diductor scars protruding slightly anterior to the anterior end of the delthyrial cavity; small but thick ridge extending anterior to the muscle field.

Brachial valve moderately and evenly convex in lateral profile and with maximum convexity at about the middle; umbonal region narrowly curved; anterior profile broadly convex and indented medially; sulcus narrow and shallow on the umbo, widening anteriorly, and occupied by 2 costae. Flanks bounding sulcus gently swollen; posterolateral slopes short and steep. Interior with thickened notothyrial platform, simple cardinal process and moderately long brachiphores; median ridge low, extending to the middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.9 | 9.7 | 10.9 | 9.2 | 6.4 |
| Paratype (pedicle valve 116878a) ... | 9.1 | ? | 10.7 | 9.8 | 3.4 |
| " (brachial valve 116878c) .. | ? | 8.7 | 10.8 | 9.2 | 2.2 |

Types.—Holotype: 116878b; figured paratype: 116878a,d, 116880, 116881; unfigured paratype: 116878c.

Horizon and locality.—Arline formation in Tennessee: 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Little Oak formation in Alabama: On U. S. Highway 31, $\frac{1}{2}$ mile north of the bridge, Pelham, Bessemer Iron District (15') Quadrangle.

Botetourt formation in Virginia: On Virginia State Highway 114, 2.3 miles west of the Montgomery-Roanoke County line, 12 miles northeast of Blacksburg.

Arline formation in Virginia: Quarry just north of Marion, Marion (T.V.A. 218-SE) Quadrangle.

Discussion.—This species is very similar to *Orthambonites rotundiformis* but is more strongly costate and the costae are more angular. *O. tennesseensis* is a much more robust shell than *O. rotundiformis*.

ORTHAMBONITES TENUICOSTATUS Cooper, new species

Plate 38, E, figures 30-40

Shell small for the genus, wider than long, subrectangular in outline; hinge narrower than the greatest shell width which is at the middle; sides nearly straight or very gently rounded; anterior margin broadly rounded; surface marked by 34 to 40 elevated and narrowly rounded costae separated by spaces equal to or slightly wider than the costae; costae appearing in 2 generations, one at the beak and the other on the anterior slope of the umbo.

Pedicle valve strongly convex in lateral profile; greatest depth at about the middle; anterior profile swollen in the middle and with moderately long and gently convex, fairly steep, lateral slopes. Umbo swollen and beak incurved; median region inflated to form an inconspicuous fold; anterior slope steep; lateral slopes gently inflated; umbonal slopes steep. Interarea moderately long, apsacline. Interior with small teeth, short, thick dental plates; umbonal cavities filled with shell material; delthyrial cavity deep; floor of muscle area slightly thickened anteriorly; vascula media and median ridge not developed.

Brachial valve gently convex in lateral profile; greatest depth located in the posterior third; anterior profile broadly convex and gently indented in the median area; sulcus originating at the umbo, widening to the anterior margin where it occupies slightly less than 2 mm. Flanks bounding sulcus gently inflated; umbonal slopes short and fairly steep; posterolateral extremities somewhat flattened. Interior with narrow, shallow notothyrial cavity, but thickened notothyrial platform; cardinal process a low ridge, not well developed; median ridge poorly defined, extending to about the middle; brachial process short and stout.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 3.5 | 3.3 | 4.3 | 3.7 | 1.8 |
| Paratype (pedicle valve 116875h).... | 6.5 | ? | 8.1 | 7.0 | 2.5 |
| “ (brachial valve 116875f)... | ? | 5.4 | 6.8 | 6.2 | 1.2 |

Types.—Holotype: 116875b; figured paratypes: 116875a,c-e; unfigured paratype: 116875f-n.

Horizon and locality.—Lower third of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its thin, elevated costae, strongly inflated pedicle valve and the implantation of a generation of costae on the anterior side of the umbo. It is close to *O. bellus* from the Chatham Hill of Virginia but is more finely and numerous costate and has a much more inflated pedicle valve.

Genus NOTHORTHIS Ulrich and Cooper, 1938

Nothorthis ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 106, 1938.

NOTHORTHIS DELICATULA Ulrich and Cooper

Plate 38, D, figures 21-29

Nothorthis delicatula ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 106, pl. 17, C, figs. 6-14, 1938.

The figures of this species are introduced for comparison with *N. tarda* from the Pratt Ferry formation of Alabama.

Types.—Lectotype: G.S.C. 9067e; paratypes: G.S.C. 9067, 9067a-d,f,g.

Horizon and locality.—Upper Canadian or younger, possibly an erratic in the lower part of the Lévis shale, Lévis, Quebec.

NOTHORTHIS TARDA Cooper, new species

Plate 38, B, figures 3-15

Shell small, subrectangular in outline; wider than long, with the hinge narrower than the midwidth; sides gently rounded; anterior margin gently rounded; anterior commissure gently sulcate; shell multicostellate, costellae increasing by intercalation in 3 generations, and numbering about 40, with 4 or 5 in a millimeter at the front margin.

Pedicle valve deep but having a moderately convex lateral profile with the maximum curvature just posterior to the middle; anterior profile narrowly domed. Umbo swollen and protruding beyond the posterior margin; median region from umbo to anterior margin somewhat narrowly swollen to form a low, rounded fold; flanks with steep slopes to lateral margin. Anterior slope gentle. Interarea short, curved, apsacline. Teeth small; delthyrial cavity deep but with small, short, slightly thickened muscle field; dental plates, short, thick, receding. Vascula media strong, narrow, widely divergent.

Brachial valve not so deep as the pedicle valve, fairly strongly convex and with the maximum convexity at about the middle; anterior profile bilobed with the center sulcate and the sides moderately domed; sulcus originating at the umbo, widening and deepening to the anterior margin where it occupies somewhat more than a quarter of the width. Flanks bounding sulcus moderately inflated but with short steep sides. Interior with thick notothyrial platform, nar-

row notothyrial cavity; short and stout brachiophores, no cardinal process, and large adductor field occupying a position on each side of the long and thick median ridge. Pallial marks present, an oblique channel appearing just outside the inner adductor scars and extending from the end of the brachiophores nearly to the front margin.

Measurements in mm.—Holotype, length 3.0, brachial length 2.7, midwidth 3.5, hinge width 3.1, thickness 1.8.

Types.—Holotype: 116851d; figured paratypes: 116851a-c, e-j.

Horizon and locality.—Pratt Ferry formation (lower third) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species differs from *N. delicatula* Ulrich and Cooper from the Lévis boulders in being somewhat smaller, much deeper and more convex in lateral profile, and in having a rounder outline. Furthermore, the interior of *N. tarda* has much more strongly impressed muscle scars and pallial marks. *Nothorthis tarda* is abundant in the Pratt Ferry formation and can be obtained by etching this limestone in acetic acid.

NOTHORTHIS TRANSVERSA Cooper, new species

Plate 38, F, figures 41-58

Shell small, rectangular in outline, with rounded sides and rounded postero-lateral extremities. Anterior commissure deeply sulcate. Surface marked by fine intercalated costellae, about 28 to 34 in number.

Pedicle valve moderately convex in lateral profile, strongly arched and somewhat narrowly rounded medially in anterior profile; median region and umbo strongly swollen, the swelling continued anteriorly to form a fold marked medianly by a strong costella extending from beak to margin; sides gently inflated and sloping steeply to the lateral margins.

Brachial valve moderately convex in lateral profile; broadly and gently convex in anterior profile; sulcus originating at the umbo, wide and deep and occupying more than half the width at the front margin. Flanks bounding sulcus gently inflated and with gentle slopes.

Measurements in mm.—Holotype, length 2.7, brachial length 2.4, midwidth 3.4, hinge width 2.9, thickness 1.5.

Types.—Holotype: 117986; figured paratypes: 117985a-e.

Horizon and locality.—Pratt Ferry formation (lower third) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species differs from *N. tarda* in its more transverse outline.

Genus NICOLELLA Reed, 1917

Nicolella REED, Trans. Roy. Soc. Edinburgh, vol. 51, pt. 4, p. 860, pl. 10, figs. 25-27, 1917.—

SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 77, 1932.

The features that distinguish *Nicolella* are not in themselves distinctive but as a combination are quite characteristic. The ornamentation generally consists of bold, strong angular costae with anterior bifurcations. The fine ornament

superimposed over the costae consists of concentric fila only; the fine radial lines often seen in *Orthambonites* are completely lacking. *Nicolella* differs from *Orthambonites* and most other members of the Orthidae in the possession of prominent chilidial plates. These are an unusual feature in the Orthidae and their strong development in this genus is a very distinctive feature. Internally *Nicolella* is like *Orthis*.

In the United States one species, *Nicolella agilera* Willard, was placed in this genus, but study of the type specimens shows it to be a decorticated example of *Productorthis*. A genuine *Nicolella* is present in the upper part of the Chambersburg limestone, and specimens have been taken from Pennsylvania and Virginia. This species has the typical concavo-convex form and the chilidial plates but is more finely costellate than usual for the genus. Another species occurs in the Trenton limestone at Rochdale, near Poughkeepsie, N. Y.

NICOLELLA ACTONIAE (Sowerby)

Plate 39, E, figure 20

Specimen introduced for comparison with American species. Note chilidial plates in brachial valve.

Figured specimen.—109888.

Horizon and locality.—Lyckholm formation (F 1a): Moe near Taps, Estonia.

NICOLELLA ANGULATA Cooper, new species

Plate 42, H, figures 45-47

Shell large for the genus, concavo-convex; wider than long; hinge forming the widest part of the shell; sides gently curved; anterior margin broadly rounded; anterior commissure broadly sulcate; surface marked by strong angular costae, 16 to 22, with bifurcations near the margins in large specimens.

Pedicle valve strongly convex in lateral profile and with a strongly rounded umbonal region; anterior profile strongly convex, with steep slopes to the lateral margins; median region inflated.

Brachial valve moderately concave and with the most concave part in the median area; posterolateral areas flattened.

Measurements in mm.—Holotype, length 10.2, brachial length 9.2, width 12.5, hinge width 14.4+, thickness 2.9.

Types.—Holotype: 116888.

Horizon and locality.—Wappinger formation in New York: On Wappinger Creek at Rochdale, $4\frac{1}{2}$ miles east-northeast of Poughkeepsie, Poughkeepsie (15') Quadrangle.

Discussion.—This species is quite unlike *O. strasburgensis* because of its strongly angular, unusually strong costae.

NICOLELLA STRASBURGENSIS Butts

Plate 39, B, figures 7-11

Nicolella strasburgensis BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 110, pl. 95, figs. 32, 33, 1942.

Fairly large for the genus, wider than long and with hinge narrower than the greatest shell width which is at or near the middle. Cardinal extremities rounded. Lateral margins gently rounded, anterior margin moderately rounded. Surface marked by strong angular costae that increase by intercalation: besides the primary costae, two sets of costae appearing, one near the middle and the other on the anterior and lateral margins. Strong, zigzag concentric growth lines over entire surface.

Pedicle valve moderately convex in lateral profile and somewhat more strongly convex in anterior profile. Umbonal region swollen, the swollen part continued anteriorly nearly to the front margin to form a poorly defined fold. Slopes to cardinal extremities fairly steep in adults. Cardinal extremities deflected slightly. Interarea nearly othocline, slightly curved. Beak overhanging interarea slightly. Delthyrium open. Interior with short dental plates and short cordate muscle area. Diductor scars fairly large, adjustor scars small. Vascula media indistinct but typically orthoid.

Brachial valve moderately concave with the deepest portion along the middle line. Umbonal region concave. Flanks bounding longitudinal concave area nearly flat. Interarea short hypercline. Chilidium small.

Measurements in mm.—Lectotype, length 20.3, width 23.1, hinge width ? thickness $3\frac{1}{2}+$.

Types.—Lectotype: 97549a; figured paratype: 97549c; figured hypotypes: 109889a,b; unfigured paratype: 97549b.

Horizon and locality.—Oranda formation in Virginia: Along the railroad tracks $\frac{1}{4}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle; 200 yards east of Hupp Hill, 1 mile north of Strasburg, Strasburg (15') Quadrangle.

Same formation in Pennsylvania: 1 mile northwest of Guilford Spring, Chambersburg (15') Quadrangle.

Discussion.—This species is characterized by its concavo-convex outline, the fine angular costae, and the strong fila and growth lamellae. It differs from members of the genus *Cyrtonotella* by its angular and coarser ornamentation and the less flaring dental plates. The species is rare.

Genus CYRTONOTELLA Schuchert and Cooper, 1931

Cyrtonotella SCHUCHERT and COOPER, Amer. Journ. Sci., ser. 5, vol. 22, p. 243, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 77, 1932.

Planidorsa SCHUCHERT and COOPER, Amer. Journ. Sci., vol. 22, p. 244, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 100, 1932.

Cyrtonotella is another of the Baltic types that appears in the lower part of the Middle Ordovician sequence of the Southern Appalachians. Specimens generally are rare and scattered but the locality $\frac{1}{2}$ mile southwest of Catawba, Va.,

has yielded many. In general the genus can be recognized by its concavo-convex outline and its usually fine costae or strong costellae. The outline is thus similar to that of *Orthis* ss. to which the genus is most closely related. The pedicle interior is characterized by short and flaring dental plates and a muscle field rhomboidal in outline. Inside the brachial valve the cardinalia are distinctive. The brachioophores are characteristically orthoid but are very thin and incline laterally from the notothyrial margin at a very low angle. They bound narrow slitlike sockets. The cardinal process has a short shaft, and the myophore may be more or less crenulated. The median ridge is short and the adductor field small.

Cyrtonotella is commonest in the lower part of the Middle Ordovician. Specimens in the collection, but too poor for identification or description, were taken from the Meadow Marble and "Ottosee" in the neighborhood of Knoxville, Tenn. It is also fairly common in the Tellico iron ore and limestones, but no specimens in the collection were good enough for description or identification. The genus ranges as high as the Benbolt but has not yet been seen above. Although *Cyrtonotella* is fairly common in parts of the Appalachians, it is known from western United States only from the shales between the Eureka sandstone and the upper Pogonip, where it is rare.

In this monograph the genus *Planidorsa* Schuchert and Cooper is placed in synonymy with *Cyrtonotella*. Opportunity to examine good brachial interiors of *Planidorsa* shows that genus to have the characteristics of *Cyrtonotella*. The pedicle interior of the genera is likewise very close. Schuchert and Cooper are mistaken in their comparison of the pedicle musculature of *Planidorsa* to *Multicostella*. The musculature is actually almost identical to *Cyrtonotella*. Species assigned previously to *Planidorsa* are usually more finely costellate than typical *Cyrtonotella*, and the brachial valve is often less concave, but these features do not at present seem sufficiently important for maintaining the name *Planidorsa*. In absence of significant interior differences between the two genera it seems best to submerge *Planidorsa*. At best, under modern methods it could be used only as a subgenus.

CYRTONOTELLA BELLA (Schuchert and Cooper)

Plate 4I, E, figures 20-25

Planidorsa bella SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 101, pl. 16, figs. 24, 25, 1932.

Shell fairly large, planoconvex to gently concavo-convex in lateral profile, wider than long with the hinge forming the widest part. Cardinal extremities varying from nearly a right angle to alate. Lateral margins sloping medially; anterior margin broadly rounded. Anterior commissure rectimarginate. Surface multicostellate, costellae elevated and very narrowly rounded and separated by interspaces about equal in width to the width of the costellae or slightly wider. Costellae increasing by implantation and bifurcation in 4 generations. About 7 or 8 costellae in a space 5 mm. at the front margin of an adult.

Costellae crossed by fine elevated fila, about 5 in 1 mm. near the center of the pedicle valve.

Pedicle valve moderately convex in lateral profile with greatest convexity located in the posterior half; anterior profile with a low hump medially from which the sides descend in a slightly concave slope. Median region from umbo to anterior margin moderately swollen to form a poorly defined fold. Umbo convex, beak protruding slightly posterior to the posterior margin. Flanks flat or slightly concave and descending gently to the margins. Umbonal slopes moderately steep. Interarea slightly longer than the one on the brachial valve, strongly curved, anacline to apsacline.

Brachial valve flat to gently concave in lateral profile, sulcus originating at the beak, shallow, and generally disappearing in the anterior half to third which is flattened to meet the anterior margin. Flanks flat to very gently convex; cardinal extremities flattened. Interarea long, flat, anacline.

Brachial interior with erect cardinal process having a short shaft, trilobed myophore in which the median lobe is carinate and elevated, suggesting that of *Valcourea*. Median ridge short, not reaching one-third the length.

Measurements in mm.—

| | | Length | Brachial length | Width | Hinge width | Thickness |
|----------|----------------|--------|-----------------|-------|-------------|-----------|
| Hypotype | (110349a)..... | 21.1 | 20.3 | 26.8 | 24.7 | 5.1 |
| " | (110348a)..... | 16.6 | 16.0 | 19.8 | 20.6 | 5.0 |
| " | (110348b)..... | 13.4 | 12.9 | 16.0 | 14.7 | ? |

Types.—Holotype: Y.P.M. S764; figured hypotypes: 110348a,b; measured hypotype: 110349a.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: On the Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; on the road to Washburn, $4\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; Maynardville Pike, 1.7 miles north of Hall Crossroads, Fountain City (T.V.A. 146-SW) Quadrangle.

CYRTONOTELLA CRASSICOSTELLA (Schuchert and Cooper)

Planidorsa crassicostella SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 101, pl. 16, figs. 22, 27, 1932.

Type.—Holotype: Y.P.M. 763.

Horizon and locality.—Benbolt formation in Virginia: Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

CYRTONOTELLA FASCICULATA Cooper, new species

Plate 41, A, figures 1-3

Shell small for the genus, more than $1\frac{1}{2}$ times wider along the hinge than long; cardinal extremities alate, acutely angular. Lateral margins sloping inward; anterior margin broadly rounded. Anterior commissure slightly sulcate. Surface

multicostellate, costellae high and narrowly rounded, primary costellae strong and standing above the others; 3 generations of costellae are intercalated, the last generation appearing near the margin and tending, with the major costellae, to form prominent fascicles. About 10 costellae including all sizes may be counted at the median part of the front margin.

Pedicle valve moderately convex in lateral profile, gently convex and humped slightly in the middle in anterior view. Median region slightly swollen; slopes to cardinal extremities concave, gentle. Interarea short, curved, anacline.

Brachial valve slightly concave in lateral profile; sulcus originating almost at the posterior margin, widening rapidly anteriorly and extending to the anterior margin. Flanks flattened; cardinal extremities flat and deflected slightly toward the pedicle valve.

Measurements in mm.—Holotype, length 9.8, brachial length 9.2, width 13.0, hinge width 17.1, thickness 2.3.

Type.—Holotype: 110356.

Horizon and locality.—Benbolt formation in Virginia: 4 miles east-northeast of Gate City, Gate City (T.V.A. 188-NE) Quadrangle.

Discussion.—This species differs from *P. bella* in possession of more strongly differentiated and more pronounced fasciculation of the costellae.

CYRTONOTELLA GRANDISTRIATA (Willard)

Plate 39, D, figures 16-19

Rafinesquina grandistriata WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 282, pl. 2, fig. 11, 1928.

Dinorthis ? sp BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, pl. 80, figs. 18, 19, 1942.

Shell large for the genus, wider than long and with the hinge forming the greatest width. Cardinal extremities acute, alate. Lateral margins sloping medially; anterior margin broadly rounded. Surface multicostellate, costellae high and narrowly rounded, appearing in 4 generations by implantation and bifurcation. Primary and secondary costellae the stronger and tending to group the ternary and quaternary costellae into fairly well marked fascicles.

Pedicle valve strongly convex in lateral profile in the posterior half, gently convex in the anterior half. Anterior profile broadly convex with the median part the most convex. Umbonal region moderately convex, but the region just anterior to the umbo swollen and the valve somewhat inflated nearly to the front margin along the median line. Slopes to cardinal extremities steep, those to the anterior and anterolateral margins less steep.

Brachial valve moderately concave in lateral profile; umbonal region slightly convex. Posterior to the middle the valve becomes moderately concave, and this portion is the most concave part. Flanks slightly convex and cardinal extremities flattened.

Pedicle interior with widely flaring dental plates; brachial interior with short and small brachiophores, small cardinal process.

Measurements in mm.—Hypotype (pedicle valve 109857), length 22.7, width 28.2, hinge width 35.2?, thickness 4.8.

Types.—Figured hypotypes: 99262a, 109846a, 109854a; unfigured hypotypes: 99262b, 109846b, 109854b-e, 109857.

Horizon and locality.—Effna formation in Virginia: At Tilson Mill, 16 miles northeast of Marion; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: Opposite road intersection with Hays Creek, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Discussion.—The ornamentation and strong convexity of this species preclude its assignment to *Rafinesquina*. Although the specimens available for study are not good, as they are preserved in a crystalline limestone, details of the interior obtained from the limestone specimens and a good silicified brachial valve indicate affinities with *Cyrtotonotella*. The species differs from *C. virginienensis* and *C. subplana* in the stronger fasciculation of the costellae.

CYRTONOTELLA MAGNA Cooper, new species

Plate 41, C, figures 8-16; plate 41, D, figures 17-19; plate 50, A, figures 1-6

Shell large for the genus, wider than long with the hinge forming the widest part; cardinal extremities acute in the young, obtuse in the adult; profile with gently concave brachial valve and strongly convex pedicle valve; surface multi-costellate, costellae elevated, narrowly rounded and separated by striae slightly less than the width of the costellae; 7 to 8 costellae in 5 mm. at the front margin.

Pedicle valve strongly convex in lateral profile but with the greatest convexity in the posterior half; anterior profile with median region somewhat strongly humped and with long, moderately steep slopes to the sides; umbo and median region swollen, the swelling continuing to the anterior margin indistinctly; posterolateral areas broad, flattened; umbonal slopes long and gently concave. Interarea short, narrowly curved; beak strongly incurved; umbo protruding slightly posterior to the posterior margin.

Brachial valve very slightly concave in lateral profile; umbo depressed by a broad sulcus which forms a prominent cavity in the median region of the valve but disappears toward the anterior margin; flanks bounding sulcus flattened; posterolateral areas flat. Interarea short, anacline. Chilidial plates small; cardinal process a short ridge; median ridge short, extending for about one-fourth the length; adductor field small; brachioophores short and thin.

Measurements in mm.—Holotype, length 22.4, brachial length 21.2, width 28.9, hinge width 27.7, thickness 6.9.

Types.—Holotype: 116897b; figured paratypes: 116897a,c, 116898, 116899a; unfigured paratypes: 116897d; 116899b-e; figured specimen: 110353a.

Horizon and locality.—Lower Sevier formation in Tennessee: On the east side of the road 0.2 mile north-northwest of Gooseneck, Louisville (T.V.A. 138-SE) Quadrangle; $\frac{1}{4}$ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle; 1 mile by road northwest of Big Springs, Binfield (T.V.A. 139-NE) Quadrangle; 2 miles southeast of Friendsville, Binfield (T.V.A. 139-NE) Quadrangle; 1 mile south of Athens, Athens (T.V.A. 125-NE) Quadrangle.

Discussion.—This species is difficult to separate from *C. bella* (Schuchert and Cooper) because the details of the ornamentation are very close. Nevertheless, *C. magna* has somewhat stronger and more closely crowded costellae. Furthermore, the brachial valve is generally more concave than that of *C. bella*. In *C. magna* the brachial valve is fairly strongly concave in young individuals, but the concavity becomes less anteriorly as the shell grows. *C. bella* on the other hand is nearly planoconvex in the young and stays that way throughout life.

CYRTONOTELLA MINOR Cooper, new species

Plate 41, B, figures 4-7

Small for the genus, wider than long, nearly planoconvex; surface costellate; costellae narrowly rounded, elevated with striae slightly wider than the costellae; 11 costellae in 5 mm. at the front margin.

Pedicle valve strongly convex in lateral profile; greatest convexity at about the middle; anterior profile narrowly convex in the median region with long and moderately steep slopes to the lateral margins; umbo narrowly swollen, the swelling continued into the midregion and indistinctly to the anterior margin. Lateral and umbonal slopes moderately steep. Umbo protruding posterior to the posterior margin; beak incurved; interarea short, orthocline.

Brachial valve with sulcate umbo; sulcus narrow, deepening toward the middle but becoming shallow and nearly obsolete at the front margin; flanks bounding sulcus nearly flat.

Measurements in mm.—Holotype, length 11.9, brachial length 11.3, width 15.1?, thickness 4.0.

Types.—Holotype: 116900a; unfigured paratype: 116900b.

Horizon and locality.—Lincolnshire formation in Tennessee: On the east side of the road $\frac{1}{4}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; on the strike of the same bed as above, $\frac{1}{2}$ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species is represented by three poor specimens only. It is finely costellate and more so than any of the other species herein described. It is evidently a rare species in the Lincolnshire and was found only in the shaly beds at Eidson.

CYRTONOTELLA SUBPLANA Cooper, new species

Plate 39, C, figures 12-15

Shell large, wider than long, with the hinge about equal to the width at the middle. Cardinal extremities a right angle. Lateral margins nearly straight; anterior margin fairly strongly rounded. Anterior commissure not folded. Surface multcostellate, costellae low and subangular and separated by interspaces wider than the width of the costellae. About 6 or 7 costellae occupying 5 mm. at the median front margin; about 90 costellae occur on the valve. Costellae crowded on the cardinal extremities. Fine ornament consisting of strong concentric fila.

Pedicle valve moderately convex in lateral profile; anterior profile with great-

est convexity in the median region; umbonal and posteromedian areas swollen; slopes to cardinal extremities steep, concave. Anterior and anterolateral slopes moderately steep. Interarea short, strongly curved, anacline; delthyrium wide.

Brachial valve gently concave with the maximum cavity at about the middle; sulcus originating almost at the posterior margin, thus producing a concave umbo. Sulcus wide but shallow, disappearing anteriorly near the front margin. Flanks flat to very gently convex. Cardinal extremities flattened. Interarea short; chilidial plates small. Interior with short, wide, and stout median ridge. Cardinal process erect, small; brachiophores short.

Measurements in mm.—Holotype, length 24.5, brachial length 22.1, width 28.8, hinge width 27.8, thickness 5.2.

Types.—Holotype: 109860a; figured paratype: 109860b; unfigured paratype: 109860c.

Horizon and locality.—Edinburg formation (*Cyrtototella* zone) in Virginia: Shaly beds just above the quarry $\frac{1}{4}$ mile east of Strasburg Junction; ravine at switch $\frac{1}{8}$ mile east of Strasburg Junction; Strasburg (15') Quadrangle.

Discussion.—This species differs from *C. virginianensis* Butts by its proportionately greater length in relation to width, less elevated and less crowded costellae, and more elongate interarea of the pedicle valve.

CYRTOTOTELLA SUBQUADRATA Cooper, new species

Plate 40, B, figure 11; plate 82, E, figures 21, 22

Shell large for the genus, subquadrate in outline; cardinal extremities acute in the young, obtuse in the adult; sides gently rounded; anterior broadly rounded; surface multicostellate, costellae narrowly rounded but separated by striae wider than the costellae; about 6 costellae in 5 mm. at the anterior margin.

Pedicle valve moderately convex in lateral profile with the greatest convexity in the posterior half; umbo strongly curved; anterior profile broadly convex with long and flat lateral slopes to the margins. Anterior slope long and rounded. Umbo swollen; median region swollen and somewhat inflated to the anterior margin. Umbonal slopes long, gently concave.

Brachial valve gently concave in lateral profile with the greatest concavity in the median region; umbo sulcate, sulcus shallow but deepening and widening anteriorly to a point somewhat anterior to the middle where the deepest point is reached; near the anterior margin the shell is somewhat elevated and the sulcus becomes obsolete; flanks bounding sulcus nearly flat.

Measurements in mm.—Holotype, length 23.6, brachial length 22.3, width 28.9, hinge width 22.6, thickness 7.8.

Types.—Holotype: 111803; figured paratype: 116895.

Horizon and locality.—Benbolt formation (*Echinosphaerites* beds) in Virginia: On the west slope of the hill $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle.

Benbolt formation in Tennessee: On the north side of the road, 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species differs from *C. magna* in its quadrate outline and stronger costellation; it differs from *C. bella* in its more rounded margins and its stronger concavity of the brachial valve.

CYRTONOTELLA VIRGINIENSIS Butts

Plate 40, C, figures 12-21; plate 40, D, figures 22-26

Cyrtotonotella virginienensis BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 67, pl. 80, figs. 20, 21, 1942.

Shell large, strongly concavo-convex; wider than long with a hinge wider than the shell at the middle. Cardinal extremities nearly a right angle to slightly acute. Lateral margins sloping slightly toward the middle; anterior margin broadly rounded. Anterior commissure not folded. Surface multicostellate, costellae appearing in 4 generations, all narrowly rounded, and separated by striae about equal in width to the width of the costellae, about 80 costellae at the front margin of an adult and about 7 to 9 in 5 mm. at the median portion of the front margin. Costellae with a tendency to fasciculation along the margin.

Pedicle valve moderately convex in lateral profile with the greatest convexity located in the umbonal region which is strongly curved. Anterior profile unevenly convex with the maximum convexity in the median region and the sides descending moderately. Median region swollen from umbo nearly to front margin with gentle slopes to anterior and lateral margins. Interarea short, strongly curved. Muscle area subquadrate with length and width about equal. Diductor impressions large; adductor field elongate, very narrow.

Brachial valve moderately concave with the maximum concavity between the median region and the anterior margin. Umbonal region flattened; the area anterior to the umbo slightly depressed to form a barely perceptible sulcus which is lost in the concave anterior half.

Flanks flat to slightly concave; cardinal extremities flattened. Interarea short, hypercline. Interior with short median ridge extending for about one-third the valve length. Brachioophores very short, widely divergent. Cardinal process short, small. Notothyrial edges with traces of low chilidial plates.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--|--------|-----------------|-------|-------------|-----------|
| Hypotype (complete specimen 109865b) | 20.5 | 18.1 | 26.3 | 26.8 | 3.0? |
| " (pedicle valve 109863) | 21.6 | ? | 28.3 | 29.7 | ? |
| " (brachial valve 116894a) | ? | 16.9 | 22.4 | 25.2 | ? |

Types.—Lectotype: 99263a; paratype: 99263b; figured hypotypes: 109863, 109865a,c, 109868a,b,e, 109870c; unfigured hypotypes: 109865b, 109868c,d, 109870a,b, 116894a,b; figured specimen: 109872.

Horizon and locality.—Botetourt formation in Virginia: Northeast of Catawba; junction of Virginia Highways 311 and 114, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle.

Arlene formation in Tennessee: North side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Arline formation in Virginia: Quarry on north side of Marion, Marion (T.V.A. 218-SE) Quadrangle.

Discussion.—This species is closest to *C. subplana* but differs in having a more concave brachial valve, less numerous, narrower, and more elevated costellae and more swollen umbonal region on the pedicle valve.

CYRTONOTELLA ? sp. 1

Plate 32, F, figures 16-21

Under this heading is placed a lot of six specimens that have suffered some distortion with the result that uncertainty exists as to their proper classification. The shells are finely costellate with about 3 costellae to the millimeter. They are concavo-convex to nearly planoconvex, and the brachial interiors are most like *Cyrtonotella*. The species are suggestive of the fine-lined *Cyrtonotellas* that occur in the Hogskin member of the Lincolnshire formation, the Red Knobs formation (not described), and possibly the Benbolt formation.

Figured specimens.—109867a-d.

Horizon and locality.—Botetourt formation in Virginia: On Hays Creek, 2 miles northeast of Brownsburg, Lexington (15') Quadrangle.

TAPHRORTHIS Cooper, new genus

(Greek *taphros*, ditch)

Shell subquadrate to subrectangular in outline; sides rounded; anterior margin gently rounded to truncate; hinge straight, generally narrower than the greatest shell width which is usually at or near the middle; biconvex, the pedicle valve having the greater convexity; surface costellate, costellae appearing in 5 generations, 1 at the beak, 1 on the anterior slope of the umbo, and 3 anterior to the umbo; spaces between costellae and surface of costellae occupied by coarse concentric fila.

Pedicle valve with delthyrium modified by more or less clearly defined lateral plates; teeth small, triangular, with shallow fossettes; dental plates short, receding and divergent; umbonal cavities mostly filled by callus; delthyrial cavity wide and deep; muscle field orthoid extended anterior to the ends of the dental plates; muscle field crudely heart-shaped; diductor scars large, linear; adductor field small, divided by a median ridge extending as far as the middle; vascula media not strongly impressed.

Brachial valve with fairly deep notothyrial cavity; notothyrial platform thick, continuous with the median ridge which is low, narrow, and extends to about the middle of the valve; anterior of notothyrial platform somewhat excavated; brachiophores short, supported by callus on the inner edge of the notothyrial platform; cardinal process poorly developed forming a low, inconspicuous ridge. Adductor field large.

Genotype.—*Taphrorthis emarginata* Cooper, new species.

Discussion.—Of described genera, *Taphrorthis* most resembles *Glossorthis* Öpik from the Middle Ordovician of Estonia. The two genera differ in many

details. For example the ornamentation of *Glossorthis* consists of strong sub-angular costae whereas the ornamentation of *Taphrorthis* is costellate. Furthermore *Glossorthis* is not provided with more than an incipient sulcus in the young. In adults the sulcus is completely lost.

Inside the pedicle valve *Glossorthis* frequently has a strong lifting of the muscle field on a callosity to produce a pseudospondylium. In *Taphrorthis* this tendency, although present, never takes a very tangible form. Inside the brachial valve the cardinal process of *Taphrorthis* never forms the high and thick septum that is characteristic of *Glossorthis*.

TAPHRORTHIS EMARGINATA Cooper, new species

Plate 38, A, figures 1, 2; plate 40, A, figures 1-10; plate 49, B, figures 5-10

Shell subrectangular in outline, attaining a width of about $\frac{5}{8}$ inch; hinge narrower than the greatest shell width which is at about the middle; cardinal extremities obtuse; sides gently rounded; anterolateral extremities narrowly rounded; front margin indented; biconvex, the pedicle valve having the greater convexity; surface multicostellate, costellae unequal in size, appearing in 4 generations, 1 just anterior to the beak, 1 anterior to the umbo, and 2 between that point and the anterior margin; about 10 costellae in 5 mm. at the front margin.

Pedicle valve moderately convex in lateral profile and with the greatest convexity in the posterior half; anterior profile moderately convex and with long moderately steep slopes; umbonal region inflated; shallow sulcus developing anterior to umbo and causing emargination of the front margin; flanks gently swollen; posterolateral extremities small; umbonal slopes short and steep; inter-area curved apsacline; beak incurved.

Brachial valve moderately convex in lateral profile and with the maximum depth in the posterior half; anterior profile depressed medially but with somewhat narrowly rounded flanks bounding sulcus and steep, short lateral slopes. Sulcus originating at the umbo and extending to the anterior margin where it occupies a third the shell width; posterolateral areas small; umbonal slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.0 | 10.8 | 15.0 | 11.9 | 6.8 |
| Paratype (116889c) .. | 8.9 | 7.9 | 12.4 | 10.4 | 4.7 |
| " (116889b) .. | 8.9 | 8.2 | 11.4 | ? | 4.2 |

Types.—Holotype: 116889a; figured paratypes: 117983a,b, 116889b,c; unfigured paratypes: 116889d-f, 116890, 116891a-d.

Horizon and locality.—Little Oak formation in Alabama: In a cut on U. S. Highway 31, $\frac{1}{2}$ mile north of Pelham, Bessemer Iron District (15') Quadrangle; Bailey Gap road junction with Cahaba Valley road SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., $1\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Arline formation in Tennessee: 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—See *T. peculiaris*.

TAPHRORTHIS PECULIARIS Cooper, new species

Plate 38, C, figures 16-20; plate 39, A, figures 1-6; plate 108, B, figures 6-14;
plate 108, D, figures 19, 20

Of moderate size for the genus, wider than long and with the hinge narrower than the greatest shell width which is located at about the middle. Cardinal extremities obtusely angular. Sides gently rounded; anterior margin truncated. Surface multicostellate with 4 generations of intercalated costellae besides the primary set. Strong concentric elevated lines cross the costellae and interspaces. Twelve costellae of all sizes appear in a space of 5 mm. at the front of a valve 11 mm. long.

Pedicle valve moderately convex in lateral profile and strongly convex in anterior profile. Beak erect and with prominent swollen umbonal region. Median portion of valve full and with a moderately steep anterior slope. Lateral slopes steep. Interarea long, curved, apsacline to orthocline; delthyrium open or partially restricted by narrow lateral plates. Pedicle interior with small teeth having moderately deep fossettes. Dental plates short, the umbonal cavities partially filled by callus material. Muscle area typically orthoid with a cordate outline having large diductor impressions and an elongate adductor field often slightly raised anteriorly and producing an incipient pseudospondylium.

Brachial valve gently convex in lateral profile but broadly arched and depressed medially in anterior profile. Beak small, protruding slightly posterior to the posterior margin. Umbo sulcate, the sulcus produced anteriorly to the front margin, widening in this direction but becoming shallower. Flanks bounding sulcus gently swollen and with gentle anterolateral slopes but steeper slopes to the cardinal extremities. Interior of brachial valve with a short median ridge not reaching to the middle of the valve; notothyrial platform moderately thick and united with the median ridge. Notothyrial cavity shallow; cardinal process a low, simple septum. Brachiphores short, slender and defining small, shallow sockets. Adductor field small.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 9.9 | 12.8 | 3.7 |
| Paratype (brachial valve 109883b) | 11.1 | 14.5 | 2.4 |

Types.—Holotype: 109883c; figured paratypes: 109883b,e, 116892, 116893a,b, 117984a,b,e; unfigured paratypes: 109883a,d,f-j, 117984c,d.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: Opposite the road intersection with Hay's Creek, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle; north of Virginia Highway 114, 2.3 miles west of Montgomery-Roanoke County line, about 12 miles northeast of Blacksburg, Montgomery County.

Pratt Ferry formation (lower third) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species differs from *T. emarginata* by its finer costellation, and shallow sulcus becoming obsolete anteriorly.

PLEURORTHIS Cooper, new genus

(Greek *pleuron*, rib)

Shells ranging from small to fairly large, generally subrectangular to semi-elliptical in outline; biconvex, with the brachial valve generally the deeper; hinge wide, straight, usually equal to or slightly less than the greatest shell width; shell sulcate in young stages but becoming uniplicate in the adult; surface multicostellate; shell fibrous, impunctate.

Pedicle valve with short receding dental plates, dental fossettes deep; musculature orthoid; delthyrium open. Brachial valve with short median ridge.

Genotype.—*Pleurorthis fascicostellata* Cooper, new species.

Discussion.—This genus is characterized by its fairly typical orthoid characters combined with a peculiar ornamentation. The valves are biconvex, and the brachial valves are sulcate in young and early mature stages. The sulcation, however, gives way to a more or less prominent plication. In adults and old shells the plication is broad and prominent. The fold is generally low but the sulcus in the pedicle valve is broad and deep. The great depth and breadth developed in some specimens early led to the assignment of some species of this genus to *Strophomena*. Usually the multicostellate exterior combined with the convex valves and the broad uniplicate commissure will separate this genus from other orthoids.

PLEURORTHIS CONVEXA Cooper, new species

Plate 31, D, figures 15-21

Shell small for the genus, subquadrate to subelliptical in outline; lateral margins narrowly rounded; anterior margin broadly convex; valves strongly convex; surface multicostellate to fascicostellate, 3 or 4 costellae to the millimeter and bundled in groups of 3 or 4 at the front margin.

Pedicle valve fairly strongly convex in lateral profile and with the greatest convexity at about the middle; anterior profile broadly convex and somewhat carinate medially; fold narrow and prominent on the umbo, extended forward to the anterior margin; sulcus broad and shallow, defined in the front half; posterolateral slopes concave and moderately steep. Dental plates divergent; delthyrial cavity narrow.

Brachial valve with fairly deep and narrow sulcus extending from the umbo to the anterior margin; lateral profile fairly strongly convex; greatest convexity at about the middle; fold low and ill-defined but indented by the sulcus; anterior profile broadly convex.

Measurements in mm.—

| | Length | Width | Thickness |
|---|--------|-------|-----------|
| Holotype (pedicle valve) | 7.2 | 10.5 | 1.9 ? |
| Paratype (brachial valve 116844b) | 10.0 | 13.8 | 2.8 |
| “ (“ “ 116844c) | 7.9 | 10.8 | 2.3 |

Types.—Holotype: 116844e; figured paratypes: 116844a-d.

Horizon and locality.—Boulders in the Mystic conglomerate in Quebec, Canada: Range 6, Lot 20, $2\frac{1}{2}$ miles north of Mystic, Stanbridge Township.

Discussion.—This species is fascicostellate like *P. fascicostellata* but differs in being smaller and much more convex in the profile of both valves.

PLEURORTHIS CORINNA (Billings)

Orthis corinna BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 302, fig. 292, 1865.—
HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 217, 1892.

Several specimens referred to this species resemble *P. imbecilis* (Billings) but differ in being proportionately wider and more strongly costellate.

Type.—Hypotype: 66307.

Horizon and locality.—Boulders in the Mystic conglomerate in Quebec, Canada: Range 6, Lot 20, $2\frac{1}{2}$ miles north of Mystic, Stanbridge Township.

PLEURORTHIS COSTELLATA Cooper, new species

Plate 31, C, figures 11-14

Fairly large for the genus, subrectangular in outline; sides moderately rounded; anterior margin broadly rounded; surface marked by fine rounded costellae about 4 to the millimeter at the front margin of an adult shell.

Pedicle valve with moderately convex lateral profile and the greatest depth at about the middle; anterior profile somewhat narrowly convex in the median area but with long and gentle slopes to the margins; beak slightly protruding; umbo narrowly swollen; median portion of valve swollen; sulcus defined only as a flattening of the anteromedian portion of the valve.

Brachial valve strongly convex in lateral profile and with the greatest convexity in the median region; anterior profile strongly convex with the median region swollen and the lateral slopes short and steep; umbo sulcate; sulcus short and narrow, dying out in the general swelling of the median region; postero-lateral slopes short and concave. Fold poorly defined.

Measurements in mm.—

| | Length | Width | Thickness |
|--|--------|--------|-----------|
| Holotype (pedicle valve)..... | 11.6 | 16.2 ? | 2.2 |
| Paratype (brachial valve 116845c)..... | 11.7 | 15.8 | 2.5 |

Types.—Holotype: 116845b; figured paratype: 116845c; unfigured paratypes: 116845a,d,e.

Horizon and locality.—Boulders in the Mystic conglomerate in Quebec, Canada: In Stanbridge Township, Range 6, Lot 20, $2\frac{1}{2}$ miles north of Mystic; Range 6, Lot 21, 2.6 miles north and $\frac{1}{2}$ mile east of Mystic.

Discussion.—This species is characterized by its very fine and fairly even costellae and the lack of clearly defined fold and sulcus. It differs from *P. imbecilis* which is finely costellate by its more robust form.

PLEURORTHIS FASCICOSTELLATA Cooper, new species

Plate 31, E, figures 22-27

Shell large, transversely elliptical in outline; valves subequally convex; hinge slightly narrower than the greatest shell width which is at about the middle; lateral margins gently rounded; anterior margin broadly rounded. Surface marked by costellae of unequal size, about 8 in 5 mm. at the front margin. Costellae tending to bundle in groups of 3, thus giving a fascicostellate appearance.

Pedicle valve moderately convex in lateral profile with the greatest convexity just posterior to the middle; anterior profile broadly convex; umbo narrowly convex and produced anteriorly as a faint swelling; sulcus broad, ill defined; lateral and posterolateral slopes gently concave. Interior of pedicle valve with short dental plates and narrow delthyrial cavity.

Brachial valve with moderately convex lateral profile, most convex in the posterior third; anterior profile broadly convex; sulcus narrow and deep at the umbo and continuing anteriorly for two-thirds the length where it merges into the ill-defined fold. Lateral slopes gently concave. Brachial valve as defined for the genus.

Measurements in mm.—

| | Length | Width | Thickness |
|----------------------------------|--------|-------|-----------|
| Holotype (pedicle valve) | 18.0 | 28.1 | 2.7 ? |
| Paratype (" " 116841b) | 12.7 | 19.7 | 2.1 |
| " (brachial valve 116841c) | 16.8 | 27.8 | 3.5 |
| " (" " 116841d) | 14.2 | 23.3 | 3.0 |

Types.—Holotype: 117982; figured paratypes: 116841b-d,g,i; unfigured paratypes: 116841a,e,f,h.

Horizon and locality.—Boulders in Mystic conglomerate in Quebec, Canada: In Stanbridge Township, Range 6, Lot 20, 2½ miles north of Mystic; Range 6, Lot 21, 2.6 miles north and ½ mile east of Mystic.

Discussion.—This species is characterized by its strongly fasciculate ornamentation and its large size. Indications are that the species attains a width of nearly 2 inches. The large shells are fairly strongly sulcate anteriorly and were originally mistaken for *Strophomena* although the ornamentation is not in accord with such an identification. *Pleurorthis fascicostellata* is more transverse than *P. imbecilis* and attains a much larger size.

PLEURORTHIS IMBECILIS (Billings)

Plate 32, B, figures 2-4

Strophomena imbecilis BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 219 (adv. sheets, 1862), 1865.

Shell elliptical in outline; surface marked by fine, narrowly rounded costellae, 3 to 4 in 1 mm. at the front margin.

Pedicle valve with lateral profile strongly convex in umbonal region but flat anteriorly; anterior profile broadly convex; sulcus broad and deep, originating about 3 mm. anterior to the beak; sulcus bounded by 2 fairly strong plications;

umbo somewhat swollen; lateral and posterolateral slopes gently concave. Pedicle valve with strongly divergent dental lamellae.

Brachial valve with lateral profile more convex than that of the pedicle valve, most convex in the median and umbonal region; anterior profile broadly and strongly convex; sulcus shallow, short and confined to the umbonal region; median region broadly swollen to form an ill-defined fold; posterolateral slopes steep and concave.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------------------|--------|-------|-----------|
| Lectotype (pedicle valve 559b)..... | 7.1 | 11.4 | 1.9 ? |
| Paratype (brachial valve 559)..... | 7.9 | 12.7 | 2.0 |

Types.—Lectotype: G.S.C. 559b; paratype: G.S.C. 559; figured hypotypes: 116842a,b, 116843.

Horizon and locality.—Table Head series in Newfoundland: Portland Creek; Table Point, Table Point Cove.

Discussion.—This species is characterized by its small size and the finely costellate exterior. In these respects it differs from all other described forms of this genus.

PLEURORTHIS TRITONIA (Billings)

Plate 31, F, figures 28, 29

Orthis tritonia BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 76, fig. 69 (adv. sheets, 1862), 1865.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 217, pl. 7A, figs. 12, 13, 1892.

Orthis ? tritonia (Billings) ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 105, pl. 18C, figs. 12, 13, 1938.

Types.—Holotype: G.S.C. 807.

Horizon and locality.—Probably of the age of the youngest boulders of the Mystic Conglomerate in Limestone No. 2, Lévis, Quebec, Canada.

PLEURORTHIS sp. 1

Plate 32, A, figure 1

Shell of about medium size for the genus; subelliptical in outline; sides rounded; anterior margin broadly rounded; surface marked by fairly coarse costellae arranged in bundles of 3 at the anterior margin and with about 3 to the millimeter.

Pedicle valve moderately convex; greatest convexity in the umbonal region; anterior profile somewhat triangular with the median region swollen and somewhat narrowly rounded and the slopes flat, long, and moderately steep; fold not well defined anteriorly; sulcus not well defined.

Brachial valve moderately convex with the greatest convexity in the median region; anterior profile broadly convex, depressed medially by the narrow sulcus; umbo sulcate; sulcus disappearing in the median swelling; fold ill defined.

Measurements in mm.—

| | Length | Width | Thickness |
|------------------------------|--------|-------|-----------|
| Pedicle valve (116847)..... | 10.5 | 14.8 | 2.5 |
| Brachial valve (116846)..... | 9.4 | 12.5 | 2.0 |

Figured specimen.—116846; described specimen: 116847.

Horizon and locality.—Table Head series in Newfoundland: At Table Point; south side of Stearing Island, Cow Head, Lower Head.

Discussion.—This species is suggestive of *P. fascicostellata* but differs in proportions, size and details of the ornamentation.

PLEURORTHIS sp. 2

Plate 32, C, figures 5, 6

A fine silicified pedicle valve has the following characters: subquadrate in outline; sides gently rounded, anterior margin broadly rounded. Surface costellate, costellae bifurcating and somewhat bundled near the middle, fairly evenly spaced along the anterior margin, about 2 to the millimeter.

Umbo swollen; sulcus originating at about the middle, broad and shallow but producing a short tongue; folds bounding sulcus somewhat narrowly rounded; posterolateral and lateral slopes long and steep. Lateral profile convex with the greatest convexity in the umbonal region. Anterior profile with steep sides but somewhat sunken median region.

Interior with wide and deep delthyrial cavity; dental plates short and receding; teeth small but with deep fossettes. Lateral plates along the delthyrial edge narrow. Muscle area large but individual scars not visible in the specimen.

Measurements in mm.—116848, length 11.7, width 14.5+, thickness 5.0.

Figured specimen.—116848.

Horizon and locality.—Lower middle part of the Table Head series in Newfoundland: North of Table Head.

Discussion.—This specimen may be conspecific with *P. imbecilis*, but the unusual preservation does not permit accurate comparison with the usual decorticated specimens of *P. imbecilis*.

Subfamily PRODUCTORTHINAE Schuchert and Cooper, 1931

Aberrant and specialized Orthacea characterized by exceedingly short interareas or none at all and having the exterior form of the productid brachiopod. Muscles of the pedicle valve deeply entrenched; brachial valve with much shortened brachiophores.

Genus PRODUCTORTHIS Kozłowski, 1927

Productorthis KOZŁOWSKI, Bibl. Liberae Polonae, fasc. 17 (separate), pp. 1-21, 1927.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 82, 1932.

This genus is characterized by its external resemblance to the productids of the Carboniferous and Permian. The pedicle valve, like that of "*Productus*," is usually convex. Some details of the ornament are quite unlike those of "*Pro-*

ductus." Spines have not been observed in the Ordovician homeomorph, and a strongly lamellose shell like that of *Productorthis* is not a characteristic feature of the Carboniferous productids. Internally, of course, the resemblance to "*Productus*" is very remote except for the hinge.

The delthyrial cavity of *Productorthis* is deep, and the muscles occupying it do not make a pattern readily recognizable as orthoid. The adductor field is very wide and occupies most of the delthyrial cavity. On each side of this track occurs a long, slender, and deeply impressed scar that can now only be interpreted as the place of attachment of the diductor muscles. Schuchert and Cooper regarded these scars as belonging to the adjustor muscles, but the Virginia specimens, particularly the one illustrated on plate 56, B, figures 14 and 17, make it necessary to revise this view. It will be noticed that a narrow pallial trunk extends from the anterior end of these slender scars. These trunks are undoubtedly the *vascula media* which always originate at the anterior ends of the diductor scars. Adjustor marks were not definitely seen in any of the specimens, and it is assumed therefore that if these muscles were present they were situated on the sides of the delthyrial cavity and left no visible marks. In the Virginia material the dental plates are not strongly marked because they are partially obliterated by callus deposited in the umbonal cavities. In old specimens the dental plates are not visible.

The interior of the brachial valve of *Productorthis* is as distinctive as that of the pedicle valve, but the orthoid characters are more clearly retained. The brachiophores are short and distinctly orthoid but are partially buried in callus that surrounds their anterior ends to form a cuplike socket. The cardinal process is large with a long oblique shaft that extends into the interior. The myophore face is narrowly elliptical and bears a sharp, slender median carina. The postero-dorsal extremity of the cardinal process is partially or wholly covered by a small elliptical or circular plate which is undoubtedly a modified chilidium. The adductor field of the Virginia specimens, like their European relatives, are divisible into 6 individual scars. The posterior pair are short and wide. The anterior group is divisible into a larger median pair and a smaller outer pair. The median ridge is low and extends for the length of the adductor field which may or may not extend as far as the middle of the valve.

Prior to the present study *Productorthis* was only known outside of Europe in South America, and Kozłowski has speculated on its absence from North America. The interesting feature of the North American specimens is their large size, which is about twice that of the usual European representatives. So far the genus is known only from Virginia and Alabama where it is a rare fossil at all its localities. Two specimens only are known from the Arline formation in the form of a species resembling *P. eminens* (Pander) but much larger. The same species is known from the Little Oak formation of Alabama and the Botetourt formation of Virginia. The reefy masses of the Effna limestone in Virginia have yielded interesting species of this genus which seem to be restricted to this peculiar environment.

PRODUCTORTHIS AGILERA (Willard)

Plate 56, B, figures 6-25

Nicolella agilera WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 272, pl. 3, fig. 7, 1928.

Shell large for the genus, slightly wider than long, with the width of the hinge less than or greater than the width at the middle. Cardinal extremities in young specimens acute but in adults or old individuals forming a right angle or obtuse. Sides oblique to rounded and the anterior margin broadly rounded. Surface marked by distant costellae, 3 to 6 in the space of 5 mm. at the front margin. Lamellae numerous and closely crowded anteriorly.

Pedicle valve moderately convex in lateral profile with the most convexity in the posterior half; anterior profile broadly convex, with long moderately steep slopes. Umbonal and median regions full with steep umbonal slopes and moderately steep lateral slopes. Anterior slope long, moderately steep. Beak incurved, beak and umbo protruding posterior to the posterior margin. Interior with deep delthyrial cavity, thickened muscle platform with adductor track. Diductor scars long and slender.

Brachial valve moderately convex with the front third somewhat flattened; anterior profile broadly and gently convex with the margins more or less reflected in a brachial direction. Median region swollen gently with gentle slopes leading into shallow troughs produced by the margins which are deflected in the direction of the brachial valve. Interior with ponderous cardinal process and short, low median ridge. Adductor field small, rectangular.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------------|--------|-------|-------------|-----------|
| Holotype | 17.5 | 18.7 | 21.9 ? | 3.9 |
| Hypotype (109890d) | 27.3 | 31.0+ | 24.0+ | 11.5 |
| “ (brachial valve 109891a). .. | 15.6 | 22.6 | 23.2 | ? |

Types.—Holotype: M.C.Z. 8607; figured hypotypes: 109890a-d, 109891a,f,g, 109895a-c, 109896; unfigured hypotypes: 109890e-h, 109891b-e, 109895d, 109899b-d; figured specimen: 109899a.

Horizon and locality.—Effna formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; McNutt Quarry 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Discussion.—This is the largest species of the genus known in either North America or Europe and differs from its nearest relative *P. americana* in its greater size, less swollen pedicle valve, less convex brachial valve, and stronger ornamentation.

All the specimens from the Effna formation have been placed under this species although considerable discrepancy in their size occurs. None of the specimens taken from the hard limestone show the ornamentation in detail, but it seems to be about the same as that of the material taken from the shaly beds on the Porterfield reef. Most of the limestone specimens break out as a core leaving the

outer marginal frill in the rock. The inner core thus obtained differs somewhat in proportions from the complete specimens.

PRODUCTORTHIS AMERICANA Cooper, new species

Plate 49, A, figures 1-4; plate 56, A, figures 1-5; plate 82, C, figure 12

Productorthis sp., BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 42, pl. 73, figs. 26-28, 1942.

Large for the genus, length and width nearly equal. Hinge slightly narrower than the greatest width which is near the middle. Surface multicostellate and imbricate; costellae numbering about 15 in 10 mm. at the front of the holotype; imbrications about 1 mm. apart.

Pedicle valve strongly convex in lateral profile but flattened in about the middle; strongly arched but medially flattened slightly in anterior profile. Median and anterior region swollen; lateral slopes steep and concave. Umbo swollen; beak incurved and almost touching the umbo of the brachial valve. Dental plates thick; apical callosity large, excavated where the pedicle was attached. Ginglymoid joint deep.

Brachial valve moderately convex in profile, median sulcus defined at the umbo but lost toward the front of the valve. Chilidium large, circular.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-------|-------------|-----------|
| Holotype | 14.9 | 20.6 | 16.6 | 11.6 |
| Paratype (brachial valve 116887) .. | 11.4 | 14.1 | 13.8 | 1.5 |

Types.—Holotype: 98184a; figured paratypes: 98184b, 116886b, 116887; unfigured paratype: 116886a.

Horizon and locality.—Arline formation in Virginia: Quarry on north side of Marion, Marion (T.V.A. 218-SE) Quadrangle.

Botetourt formation in Virginia: North of Virginia Highway 114, 2.3 miles west of Montgomery-Roanoke County line, 12 miles northeast of Blacksburg, Montgomery County.

Little Oak formation in Alabama: From a road cut on U. S. Highway 31, $\frac{1}{2}$ mile north of Pelham, Bessemer Iron District (15') Quadrangle.

Discussion.—This species is characterized by its strongly convex valves. It differs from *P. agilera* in its size and more closely crowded ornamentation as well as the shape of the valves. This is a very rare species, only four specimens having been found.

The two specimens found in Catawba Valley, Va., and the brachial valve from the Little Oak limestone in Alabama are ornamented like the specimens from Marion, Va. They are not, however, as convex as the holotype. It appears certain that the holotype has been somewhat shortened by compression on beak and anterior margin, thus shortening and thickening the specimen.

Family HESPERONOMIIDAE Ulrich and Cooper, 1936

Transverse Orthacea with flattish or shallow valves, orthoid muscle field in the pedicle valve, orthoid brachiophores, and a simple cardinal process. Pseudodeltidium unknown, but chilidial plates or chilidium present.

Flattish orthoids are fairly common in the Table Head series and in boulders of the Mystic conglomerate. It is likely that other species of *Hesperonomiella* will be recognized among them.

Genus **HESPERONOMIELLA** Ulrich and Cooper, 1936

Hesperonomiella ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 622, 1936; Geol. Soc. Amer. Special Pap. 13, p. 123, 1938.

HESPERONOMIELLA MINOR (Walcott)

Plate 121, H, figures 20-22

This is a poorly known genus and species. The interiors have hitherto been known only from molds of the interior produced by burning off the shell. Recently a few excellent interiors of both valves were obtained from L. F. Hintze. These show the pedicle valve to have a shallow delthyrial cavity and probably short, stout dental plates. These structures if present are concealed by shell deposited on the sides of the delthyrial cavity. The teeth are so large that they seem to rest on the floor of the delthyrial cavity. Pallial marks are strongly developed and consist of strong vascula media extending anterior of the diductor scars and dividing at about two-thirds the distance from the beak. The brachial valve has short and stout brachioophores much concealed by excess shell of the notothyrial platform.

Hypotype.—117939.

Horizon and locality.—Upper part of Pogonip group=Wahwah formation in Utah: T. 22 S., R. 14 W., Confusion Range, Millard County.

HESPERONOMIELLA QUEBECENSIS Cooper, new species

Plate 172, D, figures 13-20

Shell of about the usual size for the genus, wider than long; cardinal extremities acute; hinge forming the widest part of the shell; lateral margins gently rounded; anterior margin broadly rounded; surface multicostellate but ornamentation too poorly preserved to describe accurately.

Pedicle valve gently convex in lateral profile and broadly convex in anterior profile. Umbo and median regions somewhat swollen; lateral slopes concave, short, gentle; anterior slope short and gentle; delthyrial cavity narrow, triangular; vascula media strongly developed.

Brachial valve very gently convex in lateral profile; nearly flat in anterior profile; umbonal region gently swollen; sulcus shallow and broad, extending to the anterior margin; flanks on each side of sulcus gently swollen. Brachioophores short; median ridge low, short.

Measurements in mm.—

| | Length | Midwidth | Hinge width | Thickness |
|-------------------------------------|--------|----------|-------------|-----------|
| Holotype | 14.1 | 17.6 | 17.6+ | 1.7 |
| Paratype (pedicle valve 116849d)... | 14.6 | 17.8 | 21.0 | 1.7 |
| " (brachial valve 116849b). | 10.5 | 15.8 | 17.0 | ? |

Types.—Holotype: 116849a; figured paratypes: 116849b,d,f; unfigured paratypes: 116849c,e.

Horizon and locality.—Boulders in the Mystic conglomerate in Quebec, Canada: Stanbridge Township, Range 6, Lot 21, 2.6 miles north and $\frac{1}{2}$ mile east of Mystic.

Discussion.—This species is characterized by its wide hinge and brachial valve of low convexity. It differs from *H. porcias* (Walcott) in having a stronger costellation and less convex brachial valve. The delthyrial cavity of the Quebec species is also much smaller than that of *H. porcias*.

Family ORTHIDIELLIDAE Ulrich and Cooper, 1936

Small Orthacea in which the simple cardinal process is cemented to the brachiophores by deposits of shell substance.

Genus ORTHIDIELLA Ulrich and Cooper, 1936

Orthidiella ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 621, 1936; Geol. Soc. Amer. Special Pap. 13, p. 108, 1938.

ORTHIDIELLA CARINATA Ulrich and Cooper

Orthidiella carinata ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 108, pl. 16A, figs. 1, 5, 6, 1938.

Type.—Holotype: 91296.

Horizon and locality.—Same as for *O. extensa*, below.

ORTHIDIELLA COSTELLATA Cooper, new species

Plate 30, C, figures 12-19

Shell large for the genus, subquadrate in outline; hinge forming the widest part; lateral margins very gently convex; anterior margin strongly convex; cardinal extremities acute; surface marked by fine, rounded costellae that bifurcate 2 or 3 times but are not fasciculate; about 3 costellae to the millimeter.

Pedicle valve subcarinate medially but the carina becoming lost in the swollen anterior region; lateral profile gently convex; anterior profile forming a broad triangle, fairly sharp at the apex and with long gently sloping sides; umbonal and lateral slopes long and gently concave. Pedicle interior with strong, thick teeth; dental plates nearly obsolete; deep fossette located just below teeth; delthyrial cavity deep and wide; diductor muscle scars long and slender, extending to points anterior to the middle; interarea apsacline; pseudodeltidium narrowly arched, imperforate.

Brachial valve moderately convex in lateral profile; anterior profile bilobed, the lobes low and indented by the median sulcus; umbo sulcate, sulcus continued anteriorly to the front margin where it is fairly wide; areas bounding sulcus gently swollen; posterolateral slopes gently convex. Brachial interior with median ridge extending to the middle, low and rounded and separating deeply

impressed adductor field; brachiophores short and stout, supported by shell material filling the notothyrial cavity; cardinal process long and slender.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.4 | 8.4 | 10.2 | 9.9 | 5.3 |
| Paratype (116859c)... | 7.8 | 7.0 | 8.9 | 9.0 | 3.9 |
| " (116859d)... | 10.9 | ? | 12.1 | 12.9 | 2.4 |

Types.—Holotype: 116859a; figured paratypes: 116859b-e; figured specimen: 117981a.

Horizon and locality.—*Orthidiella* zone of the Pogonip group in Nevada: At the Narrows, 2 miles up Whiterock Canyon, Roberts Mountains (1°) Quadrangle. Mottled zone 700 feet below the Eureka quartzite: Base of first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

Discussion.—This species is very close to *O. longwelli* from southern Nevada and agrees with it in many details. It differs, however, in the much finer ornamentation and the lack of any tendency for the costellae to bundle. The proportions are slightly different, and the species tends toward a larger size than *O. longwelli*.

ORTHIDIELLA EXTENSA Ulrich and Cooper

Plate 30, E, figures 21-32

Orthidiella extensa ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 109, pl. 16C, figs. 10, 11, 15-17, 1938.

Types.—Holotype: 91297; paratypes: 91297a,b; figured hypotypes: 116857a-c, e-g; unfigured hypotype: 116857d.

Horizon and locality.—Upper Pogonip group (mottled zone about 700 feet below the Eureka quartzite) in Nevada: Near the base of the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

ORTHIDIELLA LONGWELLI Ulrich and Cooper

Plate 30, D, figure 20

Orthidiella longwelli ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 109, pl. 17D, figs. 15-33, 1938.

O. striata ULRICH and COOPER, Idem, p. 110, pl. 16B, figs. 2-4, 7-9, 1938.

Examination of large suites of this species shows that *O. striata* and *O. longwelli* are in reality the same. Inasmuch as *O. longwelli* is the genotype the other species is here suppressed.

Orthidiella longwelli shows considerable variation in the costellation, outline, and profiles. One example is fairly coarsely costellate, has narrow ears and is very robust in the umbonal region. The latter feature comes about by swelling in young stages and a rapid contraction near the middle of the valve.

Types.—Holotype: 91299; paratypes: 91300a-g; holotype of *O. striata*: 91303; paratypes *O. striata*: 91304a,b.

Horizon and locality.—Pogonip group (mottled zone 700 feet below the Eureka

quartzite) in Nevada: At the base of first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle; at the Narrows 2 miles up Whiterock Canyon, Roberts Mountains (1°) Quadrangle.

ORTHIDIELLA sp. 1

Plate 30, B, figures 6-11

This species is represented by only two specimens, a complete one and a brachial valve. The cardinal extremities are produced into small ears. The valves are moderately convex with the brachial valve somewhat transversely narrowly humped in the median region. At the front margin the costellae form fascicles of 2 or 3 costellae.

Measurements in mm.—116861a, length 7.0, brachial length 6.3, midwidth 7.8, hinge width 7.1, thickness 3.9.

Figured specimens.—116861a,b.

Horizon and locality.—Pogonip group (mottled zone 700 feet below the Eureka quartzite), in Nevada: Base of first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

Genus ORTHIDIUM Hall and Clarke, 1892

Orthidium HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 244, 1892.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 110, 1938.

ORTHIDIUM BELLULUM Ulrich and Cooper

Plate 30, A, figures 1-5

Orthidium bellulum ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 111, pl. 16F, figs. 19-26, 1938.

Types.—Holotype: 92848; paratypes: 92846a-c.

Horizon and locality.—Upper Pogonip group in Nevada: In Ikes Canyon on the east side of the Toquima Range, Roberts Mountains (1°) Quadrangle.

ORTHIDIUM FIMBRIATUM Cooper, new species

Plate 31, A, figures 1-6

Shell small, resembling *Orthidium bellulum*; slightly wider than long; hinge narrower than the greatest shell width near the middle; sides gently rounded; cardinal extremities obtuse; anterior margin narrowly emarginate; valves unequally convex, the pedicle valve having the greater convexity; surface costellate and fimbriate; costellae about 4 to the millimeter at the front margin; lamellae about 2 to the millimeter; frill of a specimen about 2 mm. long measuring 1 mm.

Pedicle valve deep and strongly convex in lateral profile; greatest convexity in about the middle; anterior profile strongly convex and with a narrowly rounded summit creased by the narrow sulcus; lateral slopes flat, short, and steep; sulcus narrow, moderately deep and extending from the beak to the anterior margin. Median region swollen to form an ill-defined fold; umbo narrow,

swollen and protruding posterior to the hinge; interarea curved, approximately orthocline.

Brachial valve having about half the depth of the pedicle valve, gently convex in lateral profile and with greatest convexity in the umbonal region; anterior profile broadly convex with short and moderately steep slopes and with the median region narrowly depressed by the sulcus. Beak small, protruding slightly posterior to the posterior margin; sulcus originating at the beak and extending to the anterior margin and widening anteriorly; anterior margin with a more or less marked reentrant where the brachial and pedicle valve sulci meet; areas bounding sulcus moderately swollen; posterolateral extremities concave and with short, steep slopes.

Interior not known.

Measurements in mm.—

| | Length | Brachial length | Hinge width | Width | Thickness | Length of frill |
|-------------------------------------|--------|-----------------|-------------|-------|-----------|-----------------|
| Holotype | 4.3 | 3.9 | 3.8 | 5.0 | 2.5 | ? |
| Paratype (pedicle valve 116856b)... | 5.7 ? | ? | 5.3 | 7.3 | 2.6 | 0.7 ? |
| “ (brachial valve 116854a) .. | ? | 2.1 | 3.0 | 2.8 | ? | 1.1 |

Types.—Holotype: 116855a; figured paratypes: 116854a, 116856b; unfigured paratypes: 116854b, 116855b,c, 116856a.

Horizon and locality.—Table Head series in Newfoundland: $\frac{1}{2}$ mile north of Belle Burn; south side of Stearing Island, Cow Head; Table Point Cove.

Discussion.—This species is similar to *Orthidium bellulum* Ulrich and Cooper in its proportions and ornamentation but differs in the strong sulci on both valves and the greater depth of the pedicle valve in the Newfoundland species.

ORTHIDIUM GEMMICULUM (Billings)

Orthis gemmicula BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 75, fig. 68 (adv. sheets, 1862), 1865.

Orthidium gemmicula (Billings) HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 217, 244, pl. 7A, figs. 22-25, 1892.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 112, pl. 16G, figs. 27-35, 1938.

Hypotypes.—G.S.C. 9070,a,b,d.

Horizon and locality.—Probably late Upper Canadian (limestone No. 2) or younger, Lévis, Quebec, Canada.

Genus TREMATORTHIS Ulrich and Cooper, 1938

Tremorthis (sic) ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 112, 1938.

Trematorthis COOPER, Journ. Washington Acad. Sci., vol. 32, No. 8, p. 230, 1942.

TREMATORTHIS MASONI Ulrich and Cooper

Plate 29, A, figures 1-15

Trematorthis masoni ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 113, pl. 57A, figs. 1-9, 13, 1938.

Types.—Lectotype: 95876c; paratypes: 95876a,b,d-i; figured hypotypes: 116863a,d-g; unfigured hypotypes: 116863b,c.

Horizon and locality.—Pogonip group (mottled zone 700 feet below the Eureka quartzite) in Nevada: At the base of the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

TREMATORTHIS ROBUSTA Cooper, new species

Plate 29, C, figures 21-27

Shell subquadrate in outline with gently rounded sides and anterior margin; biconvex with the pedicle valve having the greater depth; hinge narrower than the shell width at the middle; surface costellate, 2 to 3 costellae in the space of 1 mm. at the anterior margin.

Pedicle valve with long and strongly apsacline interarea; gently convex in lateral profile; anterior profile strongly convex and with long, gently convex slopes; umbo carinate, the narrow swelling extended anteriorly to the front margin as an ill-defined fold. Pseudodeltidium narrowly arched, short and with a minute foramen.

Pedicle interior with large, thick teeth; dental plates nearly obsolete but appearing as a ridge on the sides of the delthyrial cavity; muscle area somewhat thickened; delthyrial cavity deep; vascula media subparallel.

Brachial valve marked medially by a broad and shallow sulcus extending from the beak to the anterior margin; areas bounding the sulcus gently convex; lateral profile gently and evenly convex; anterior profile broadly sulcate; posterolateral areas small, with a gentle slope.

Brachial interior with stout brachiophores, short median ridge and trilobed cardinal process.

Measurements in mm.—Holotype, length 7.3, width 7.7, hinge width 6.6, thickness 3.8.

Types.—Holotype: 116865a; figured paratype: 116865c; unfigured paratypes: 116865b,d.

Horizon and locality.—Pogonip group (mottled zone 700 feet beneath the Eureka quartzite) in Nevada: At the base of the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

Discussion.—This species differs from *T. masoni* by its robust form and the parallel arrangement of the vascula media in the pedicle valve.

TREMATORTHIS TENUIS Cooper, new species

Plate 29, B, figures 16-20

Shell large for the genus, somewhat quadrate in outline; hinge forming the widest part; sides very gently convex; cardinal extremities acute; anterior margin strongly rounded. Surface fascicostellate, costellae forming bundles of 3.

Pedicle valve subcarinate, a median costella the strongest on the valve originating at the beak and extending to the anterior margin; gently convex in lateral profile but having a greater depth than the brachial valve; anterior profile forming a low triangle with gently sloping lateral areas; beak small; interarea apsacline. Pseudodeltidium narrowly arched, foramen minute.

Brachial valve very gently convex in lateral profile; anterior profile deeply indented medianly and with lateral areas gently swollen; umbonal region sulcate, sulcus widening and deepening to the anterior margin where it is broad and deep; areas bounding sulcus forming low plications; posterolateral areas small, gently concave. Cardinal process a thin, delicate blade.

Measurements in mm.—Holotype, length 7.0, width 8.6, hinge width 9.6, thickness 2.8.

Types.—Holotype: 117978a; unfigured paratype: 117978b.

Horizon and locality.—Pogonip group (mottled zone 700 feet below the Eureka quartzite) in Nevada: At the base of the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

Discussion.—This species suggests *Orthidiella extensa* in its slender profile and deeply sulcate brachial valve; it differs from *Orthidiella carinata* in its profile and the deep sulcation of the brachial valve. It differs from *Trematorthis masoni* in being large, more strongly costellate, in having a minute foramen and in having a deeper sulcus. The species suggests *Orthidiella*, but that genus has no apical foramen. It is a more slender shell than *T. robusta*.

Family HESPERORTHIDAE Cooper, new family

Progressive Orthacea having long and wide palintropes, subreniform ovarian impressions, and subparallel vascula media. Brachiophores long and more advanced than in the Orthinae. Remnants of a pseudodeltidium and achilidium are retained in some genera. Delthyrium also margined by lateral plates in some genera.

This family is erected for the Orthacea with long, slender brachiophores which are commonly triangular in cross section. These contrast strongly with the short brachiophores of the Orthinae. Another feature of interest is the presence of a small pseudodeltidium which arches under the sides of the delthyrium at the apex of the shell. This is partially covered, in some specimens, by lateral plates that extend over the delthyrial edge.

Subfamily HESPERORTHINAE Schuchert and Cooper, 1931

Hesperorthidae with strong radial ornamentation on the exterior and without concentric lamellae.

Genus HESPERORTHIS Schuchert and Cooper, 1931

Hesperorthis SCHUCHERT and COOPER, Amer. Journ. Sci., 5th ser., vol. 22, p. 244, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 85, 1932.

Hesperorthis is distinguished from *Orthambonites*, to which it has great resemblance, by certain external and internal features. On the outside *Hesperorthis* always has strongly unequal valves, the pedicle valve is always the deeper but the brachial valve is more often gently concave, more rarely slightly convex. The palintrope of the pedicle valve is always fairly long and is usually curved.

Orthambonites on the other hand always has both valves convex although the pedicle valve is usually the deeper of the two. The palintrope of *Orthambonites* is generally short and strongly curved, often so strongly curved as to simulate the orthocline position.

The later members of *Hesperorthis* are generally provided with a pseudodeltidium. Usually this structure in the Ordovician members is located at the apex and covers but a small portion of the delthyrium. This pseudodeltidium is usually flat in profile and depressed slightly below the margins of the delthyrium. In the earlier members of the genus the pseudodeltidium is lacking or has not been observed. In these shells identification with *Hesperorthis* is based on other internal details.

Inside the pedicle valve of *Hesperorthis* the teeth are always small with small oblique fossettes; the dental plates are short and of the receding type. The muscle area is usually cordate in outline, and the vascula media are like those of *Orthambonites* and *Orthis*.

Inside the brachial valve the notothyrial platform is always well developed and thickened. The brachiophores are elongate and usually triangular in section and in this respect differ from *Orthis* and *Orthambonites*. The cardinal process is usually thickened at its base and often bears a narrow longitudinal furrow on the exposed face of the shaft.

Hesperorthis, but without a pseudodeltidium, appears first in the middle portion of the Marmor, becomes abundant (with pseudodeltidium) in the late Middle Ordovician, reaches its climax in the Richmond with a new gigantic species, and then declines into the Middle Silurian.

HESPERORTHIS ANTELOPENSIS Cooper, new species

Plate 269, C, figures 11-17

Shell of about average size for the genus, subpentagonal in outline; length and width about equal; side nearly straight, hinge width and midwidth nearly equal; anterior margin narrowly rounded; anterior commissure faintly sulcate; costae rounded, numbering 32, and with 1 or 2 fine radial lines occupying the interspaces.

Pedicle valve moderately convex in lateral profile, with the maximum convexity just anterior to the beak; anterior profile strongly domed, the median region narrowly convex and forming an indistinct fold; lateral slopes steep; ears small, approximately a right angle. Interarea long and with a long, narrow delthyrium. Pseudodeltidium small. Beak small and incurved.

Brachial valve gently concave in lateral profile, somewhat more strongly concave in anterior profile; greatest concavity near the middle and extended anteriorly to the anterior margin as a poorly defined sulcus. Flanks bounding sulcus flat; posterolateral extremities gently deflected toward the pedicle valve.

Measurements in mm.—Holotype, length 16.3, length of brachial valve 13.0, midwidth 16.3, hinge width 16.6, thickness 8.3, height 8.7.

Type.—Holotype: 124232.

Horizon and locality.—Dark shales below the Eureka quartzite in Nevada: Below two knobs of Eureka quartzite, north side of canyon 3.1 miles N. 32° E. of Blair (Segura) Ranch, Antelope Mountains, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by its straight sides, long interarea, deep pedicle valve, and strongly incurved beak. It is most like *H. colei*, but differs in having a longer and more curved interarea, deeper and more carinate pedicle valve, and a more broadly sulcate brachial valve. *Hesperorthis virginica* is not so deep as *H. antelopensis*, its interarea is more strongly apsacline, and its brachial valve is less sulcate. *Hesperorthis sulcata* of Oklahoma is not so deep as the Nevada species, and its brachial valve is more deeply sulcate, so much so that the anterior commissure is definitely and strongly sulcate.

HESPERORTHIS AUSTRALIS Cooper, new species

Plate 49, C, figures 11-15; plate 53, A, figures 1-31

Shell of medium size to small for the genus, slightly wider than long with the hinge forming the widest part or usually slightly narrower. Maximum shell width often just anterior to the hinge. Cardinal extremities varying from slightly obtuse to slightly acute. Lateral margins nearly straight and slightly oblique to very gently rounded. Anterior margin broadly rounded; the outline semielliptical. Surface costate, costae direct, narrowly rounded, and numbering 26 to 30. Interspaces occupied by several fine costellae, one of which may be stronger than the others, and by fine concentric fila. Costae seldom intercalated.

Pedicle valve with lateral profile unequally convex and with the anterior flattened; maximum convexity located just anterior to umbo. Anterior profile subcarinate with the sloping sides forming an angle slightly less than 110° . Umbonal region somewhat swollen with the swollen portion extending to the front margin as a low fold. Lateral slopes long and fairly steep. Anterior slope long but less steep than the lateral ones. Beak slightly incurved and forming an angle of about 130° to 140° . Interarea strongly apsacline, slightly curved. Delthyrium long and narrow; pseudodeltidium small.

Brachial valve with lateral profile varying from very slightly concave to distinctly but slightly convex; anterior profile the same. Median sulcus originating at the umbo, expanding rapidly anteriorly to more than half the width; flanks bounding sulcus very slightly convex; posterolateral extremities nearly flat. Interarea short.

Pedicle interior with deep, elongate delthyrial cavity bounded by strong receding dental plates. Teeth small with deep fossettes. Vascula media not strongly developed. Brachial interior with long brachioophores and stout cardinal process often supplemented by lateral bosses. Median ridge low and stout, reaching anterior to the middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.4 | 11.7 | 15.3 | 14.4 | 5.8 |
| Paratype (71965b) | 12.8 | 10.6 | 14.4 | 13.0 | 5.9 |
| " (pedicle valve 116912a)... | 19.9 | ? | 21.8 | 19.6 | 7.0 |
| " (brachial valve 116912c) .. | ? | 15.1 | 20.9 | 18.5 | 2.8 |
| " (116909a) | 9.6 | 7.8 | 10.5 | 10.4 | 5.3 |
| " (pedicle valve 109906b)... | 12.0 | ? | 12.6 | 11.4 | 4.7 |
| " (brachial valve 109906a) .. | ? | 10.6 | 13.3 | 12.4 | 1.4 |
| " (116914) | 15.2 | 12.5 | 15.9 | 13.1 | 8.4 ? |

Types.—Holotype: 109927a; figured paratypes: 71965b, 109906c,g-i, 109927b, 109928a,f, 116909a-d, 116912a-c, 116914; unfigured paratypes: 71965a, 109906a, b,d,f,j-l, 109927c-l, 109928b-e,g.

Horizon and locality.—Ridley (?) formation in Georgia: On U. S. Highway 27, 1 mile north of Rock Spring, Nickajack (T.V.A. 113-SW) Quadrangle.

Wardell formation and Wardell part of Dryden formation in Tennessee: 0.3 mile southwest of Little Barren Church on old Tennessee Highway 33, Powder Springs (T.V.A. 154-SW) Quadrangle; south of side road 1 mile northeast of Watergap south of Bray, Swan Island (T.V.A. 162-NE) Quadrangle; Evans Ferry section (*Hesperorthis* bed) on Tennessee Highway 25E, $\frac{1}{2}$ mile northeast of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; Clinch River, 12 miles northeast of Liberty Hill probably in Howard Quarter (T.V.A. 162-NW) Quadrangle=Evans Ferry section; quarry $\frac{1}{2}$ mile northeast of the depot at Clinton, Clinton (T.V.A. 137-SW) Quadrangle, Jacksboro, Jacksboro (T.V.A. 136-SW) Quadrangle; north of the Canyon of Gap Creek, $1\frac{1}{4}$ miles west of Arthur, Cumberland Gap (T.V.A. 153-SW) Quadrangle.

Ridley formation in Tennessee on the east side of Marshall Knobs, 5 miles south of Murfreesboro, Murfreesboro (15') Quadrangle; 0.6 mile south of Chapel Hill Methodist Church on Tennessee Highway 28, 1 mile south of its junction with Tennessee Highway 8, Sequatchie County, Daus (T.V.A. 104-SW) Quadrangle.

Wardell formation and Wardell part of Dryden formation in Virginia: North quarry on Station Creek, $\frac{1}{4}$ mile south of U. S. Highway 58, 2 miles east of Cumberland Gap, Wheeler (T.V.A. 153-SW) Quadrangle; Lloyd Carter's barn, 0.8 mile by road northeast of brick school at Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is characterized by its nearly flat brachial valve, fairly convex pedicle valve and the inconspicuous brachial sulcus. It approaches *H. tricenaria* in size, especially the large specimens occurring at Station Creek near Cumberland Gap in southwestern Virginia. Generally the species is somewhat smaller with a somewhat subcircular outline.

HESPERORTHIS BICONVEXA Cooper, new species

Plate 51, A, figures 1-6

Shell large for the genus, one-sixth wider than long with slightly obtuse cardinal extremities. Sides gently rounded; anterior margin broadly rounded. Sur-

face costate, costae numbering about 34 in an adult. Costae not greatly elevated, somewhat narrowly rounded and separated by spaces equal in width to the costae. Interspaces finely costellate.

Pedicle valve gently convex in lateral profile with the greatest convexity located in the posterior half; anterior half somewhat flattened. Anterior profile broadly convex. Median region swollen to form an indistinct fold. Lateral slopes slightly convex, not steep. Cardinal extremities somewhat flattened. Interarea moderately long, strongly apsacline.

Brachial valve moderately convex in lateral profile; anterior profile broadly convex with short lateral slopes and a median depression. Median sulcus originating at the umbo, narrow, shallow, and extending for about three-quarters the length where the valve is swollen slightly. Flanks broad and somewhat swollen with short, gentle lateral slopes. Cardinal extremities somewhat flattened. Interarea short, anacline.

Measurements in mm.—Holotype, length 17.1, brachial length 16.3, width 21.5, hinge width 20.0, thickness 8.6.

Types.—Holotype: 109962; figured paratype: 109964.

Horizon and locality.—Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This is a large species than can be recognized by its strongly apsacline pedicle palintrope, a brachial valve that is unusually convex for the genus, and by the large number of costae. Its nearest related form is *H. longirostris*, but this differs in the greater length of the pedicle palintrope, the concave to flat brachial valve, less numerous costae, and different outline in the adult.

HESPERORTHIS COLEI Cooper, new species

Plate 54, D, figures 16-21

Shell of about medium size for the genus, length and width about equal; cardinal extremities slightly obtuse or about a right angle; sides nearly straight; anterolateral areas gently rounded; anterior margin fairly strongly rounded; anterior commissure slightly sulcate; surface marked by 32 to 33 somewhat broadly rounded costae separated by spaces narrower than the costae. Strong concentric fila and fine radial lines occupy the striae.

Pedicle valve moderately convex with the greatest convexity in the posterior third; anterior two-thirds moderately steep and gently convex; anterior profile somewhat narrowly convex and with flat, steep slopes to the margins. Umbo narrowly swollen, median region gently inflated; anterior slope long; posterolateral slopes steep. Interarea long, strongly curved, strongly apsacline. Interior with large teeth, deep fossettes; dental plates short and receding; delthyrial cavity deep; muscle region somewhat elongated, somewhat thickened. Pseudodeltidium exceptionally long for the genus; lateral plates well developed, marked by an elevated ridge on each side of the delthyrium.

Brachial valve unevenly concave in lateral profile, the greatest concavity located in the posterior third, the anterior two-thirds flat to gently concave; umbo concave; sulcus shallow, originating at the umbo, widening anteriorly and form-

ing a moderately deep depression in the median and anteromedian regions. Flanks bounding sulcus flat; posterolateral regions deflected slightly toward the pedicle valve; chilidium well developed, short; cardinal process stout; brachio-phores stout, moderately long; median ridge low and long.

Measurements in mm.—Holotype, length 14.3, brachial length 11.4, width 14.9, hinge width 14.6, thickness 6.9.

Type.—Holotype: 48796.

Horizon and locality.—Decorah formation (Ion member) in Goodhue County, Minnesota: 8 miles south of Cannon Falls; in a road cut on the county highway 1.1 miles east of U. S. Highway 52 on the south edge of Cannon Falls; Wagner Hill, U. S. Highway 52, 5 miles south of Cannon Falls.

Same formation and member in Iowa: Along the Dugway, $\frac{1}{2}$ mile west of Decorah.

Discussion.—This species is characterized by having the length and width almost equal, a long interarea, and somewhat crowded costae. The species is also characterized by the unusual development of the pseudodeltidium and chilidium. In most species of *Hesperorthis* the pseudodeltidium, when present, is short and located at the posterior end of the delthyrium. In this species a pseudodeltidium measuring 4 mm. in length in a delthyrium 6.5 mm. in length has been observed. Furthermore, the pseudodeltidium is often considerably thickened and in at least three cases is swollen above the level of the interarea. A chilidium is an unusual feature in this genus, but most of the specimens of this species examined possess it. The chilidium, however, is generally short but is well arched.

Another feature of interest is the low ridge along the margin of the lateral plates bounding the delthyrium. The species differs from *H. tricenaria* (Conrad) in the excessive development of the pseudodeltidium, smaller size, more concave brachial valve, and more strongly apsacline interarea on the pedicle valve.

HESPERORTHIS CONCAVA Cooper, new species

Plate 51, E, figures 21-26; plate 54, C, figures 11-15

Shell of medium size for the genus, length and width about equal; cardinal extremities approximately a right angle or slightly obtuse; sides gently rounded; anterior margin narrowly rounded; anterior commissure rectimarginate; surface marked by about 30 narrowly rounded, strong costae separated by spaces slightly narrower than the costae. Fine costellae mark troughs of the striae.

Pedicle valve strongly convex in lateral profile with the maximum convexity slightly posterior to the middle; anterior profile strongly but broadly convex and without the median narrowing characteristic of many species of this genus; lateral slopes gently convex, steep; beak somewhat elongated, obtuse, forming an angle of about 130° ; median region strongly swollen with steep anterior, lateral, and posterolateral slopes. Fold formed by an elevated median costa extending from beak to anterior margin but most prominent in anterior two-thirds. Interarea long, fairly strongly curved, strongly apsacline; pseudodeltidium short.

Brachial valve fairly strongly concave in lateral profile with the deepest part slightly posterior to the middle; umbo gently concave, narrowly sulcate; sulcus narrow, expanding gradually anteriorly but never attaining much width; sulcus extending directly to the anterior margin and containing 2 costae; areas bounding sulcus nearly flat; posterolateral areas gently concave. Interior with long brachioophores and long, low, median ridge.

Measurements in mm.—Holotype, length 14.8, brachial length 12.5, width 16.2, hinge width 14.8, thickness, 7.0.

Types.—Holotype: 83842; figured paratype: 116917.

Horizon and locality.—Platteville formation (McGregor member) in Wisconsin: From a quarry on the south side of Ellenboro Hill halfway between Lancaster and Platteville; quarry on Wisconsin Highway 81, 1 mile northwest of Ellenboro; on road 3 miles northwest of Platteville; Lancaster (30') Quadrangle.

Platteville formation in Illinois: 1½ miles northeast of Dixon.

Chaumont formation in New York: Loose in the bed of Black River, just below the dam at the head of the island, Watertown, Watertown (15') Quadrangle.

Discussion.—This species is characterized by its strongly inflated pedicle valve which is not subcarinate as is usual in many species of *Hesperorthis*, by the fairly strongly concave brachial valve with its narrow sulcus, and by the peculiar narrow fold produced by the slightly elevated median rib. These features distinguish it from *H. australis* and from *H. colei*, which is more finely costate and not so strongly convex.

HESPERORTHIS ? COSTALIS (Hall)

Plate 32, E, figures 9-15

Orthis costalis HALL, Pal. New York, vol. 1, p. 20, pl. 4, fig. 4a, 1847.—RAYMOND, Ann. Carnegie Mus., vol. 7, p. 235, pl. 35, fig. 4, 1911.—BASSLER, U. S. Nat. Mus. Bull. 92, p. 888, 1915.

Raymond fixed the type of this species on an imperfect specimen occurring on a piece of dark limestone containing a fragment of a *Strophomena*. Raymond claims that the specimen which is from Chazy, N. Y., could have come only from Middle Chazy or Black River rocks, the only two formations having lithological characters like the fragment containing these specimens. Raymond also concludes that the specimen is closer to *Hesperorthis tricenaria* than to any other species then described from the Chazyan. It is certain that the specimen is not like any named Chazy form and that it has some of the characters of *Hesperorthis* such as the musculature and the interarea. For the present the name will have to rest on that specimen, and definition of its horizon and biological characters will have to await discovery of additional material.

Types.—Holotype: A.M.N.H. 528; figured hypotypes: 116853b-e,j; unfigured hypotypes: 116853a,f-i,k-m.

Horizon and locality.—Day Point formation (upper "orthis" bed) in New York: Quarry just north of Hotel Champlain, south of Cliff Haven, Plattsburg (15') Quadrangle.

HESPERORTHIS ? COSTELLATA Cooper, new species

Plate 82, A, figures 1-6

Shell of about the usual size for the genus, length and width about equal; sides gently rounded; hinge about equal to the midwidth; anterior margin somewhat narrowly rounded. Surface costellate, costellae intercalated in several generations, distinctly fasciculate in places at the front and numbering about 50. Stria between costellae occupied by concentric fila.

Pedicle valve unevenly convex in lateral profile, the posterior third somewhat flattened, the median third moderately convex but the anterior third again flattened. Anterior profile narrowly convex in the median region but with long, steep lateral slopes. Beak prominent; umbo narrowly convex, the narrow convexity continued anteriorly to the front margin as a poorly defined fold. Interarea long, slightly curved, and apsacline.

Brachial valve faintly convex in lateral profile and broadly but gently convex in anterior profile; sulcus shallow, indistinct, originating at the umbo and extending to the anterior margin. Flanks bounding sulcus faintly convex; postero-lateral extremities deflected and flattened in the direction of the brachial valve.

Measurements in mm.—Holotype, length 12.0, brachial length 10.0, width 13.7, hinge width 14.4, thickness 5.5.

Types.—Holotype: 116918.

Horizon and locality.—Botetourt formation in Virginia: On Virginia Highway 114, 2.3 miles west of the Montgomery-Roanoke County line, 12 miles north-east of Blacksburg, Montgomery County.

Discussion.—This species is characterized by its costellate surface and in this respect is unlike all other species of *Hesperorthis* described herein. The generic assignment is doubtful because interior details are unknown and the ornament is not like that of the majority of species.

HESPERORTHIS CRINERENSIS Cooper, new species

Plate 52, B, figures 8-15

Small for the genus, wider than long with the hinge forming the widest part; cardinal extremities forming a large acute angle; sides gently oblique; front margin strongly rounded; anterior commissure gently sulcate; surface marked by 26 narrowly rounded elevated costae separated by striae about equal in width to the width of the costae. Striae occupied by several fine radial lines.

Pedicle valve very gently convex in lateral profile; anterior profile narrowly rounded medianly and with long and steep lateral slopes; umbo narrowly swollen, the swelling continued anteriorly nearly to the anterior margin as a poorly defined fold; interarea long, nearly catacline; delthyrium open.

Brachial valve gently convex in lateral and anterior profiles; umbo sulcate; sulcus narrow, shallow, widening and deepening gradually anteriorly to the front margin; flanks bounding sulcus gently swollen; posterolateral extremities deflected slightly toward the pedicle valve; interior with a short and stout median

ridge; cardinal process a thin septum; brachiophores stout; chilidium slightly developed.

Measurements in mm.—Holotype, length 8.2, brachial length 7.8, width 10.0, hinge width 11.5, thickness 5.1.

Types.—Holotype: 110004a; figured paratype: 110004b.

Horizon and locality.—Bromide formation (Mountain Lake member-middle zone 7 of Decker) in Oklahoma: Rock Crossing of Hickory Creek approximately center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—This species is readily distinguished from *H. sulcata* which is much larger, very differently shaped, and differently ornamented.

HESPERORTHIS ? DECIPIENS (Phleger)

Orthis decipiens PHLEGER, Bull. S. California Acad. Sci., vol. 32, pt. 1, p. 17, pl. 1, fig. 2, 1933.

Horizon and locality.—Barrel Spring formation in California: In Barrel Spring Canyon, Inyo Mountains.

HESPERORTHIS DUBIA Cooper, new species

Plate 51, B, figures 7-13

Shell fairly large for the genus, slightly wider than long with the hinge forming the widest part; cardinal extremities slightly auriculate; sides gently rounded; anterior margin narrowly rounded; anterior commissure rectimarginate; surface marked by about 34 elevated, narrowly rounded costae slightly wider than the separating grooves; 2 or 3 fine costellae occupying the striae.

Pedicle valve very gently but unevenly convex in lateral profile, the greatest convexity in the posterior third or half; anterior half somewhat flattened; anterior profile narrowly humped in the median region with long, flat, and moderately steep slopes to the margins. Anterior slopes long and gently convex; beak obtuse, forming an angle of 140° to 150° ; umbo broadly swollen; median region gently swollen; interarea very slightly curved; strongly apsacline; pseudo-deltidium absent.

Brachial valve almost flat in lateral profile but with anterior portion slightly concave; anterior profile nearly flat; umbonal region gently swollen; median region and most of anterior depressed into a broad and shallow sulcus the anterior part of which is slightly elevated near the margin; flanks bounding sulcus gently and somewhat narrowly swollen; posterolateral areas flattened and deflected slightly toward the pedicle valve; interarea short.

Measurements in mm.—Holotype, length 15.4, brachial length 13.7, width 17.9, hinge width 17.3, thickness 6.4.

Type.—Holotype: 116919.

Horizon and locality.—Lower Sevier formation in Tennessee: $\frac{1}{4}$ mile north-east of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This is a large and rare species approaching *H. tricenaria* in size. It differs from that species in the lesser convexity of the pedicle valve,

nearly flat brachial valve, shorter pedicle interarea which is more steeply apsacline than that of *H. tricenaria* and much less inflated pedicle valve.

This species is also suggestive of *H. biconvexa* but has a nearly flat brachial valve rather than a gently convex one; the pedicle valve is less swollen in *H. biconvexa* and the costae are somewhat more distantly spaced.

HESPERORTHIS IGNICULA (Raymond)

Plate 51, F, figures 27-34

Orthis disparalis BILLINGS, Canadian Nat. Geol., vol. 4, p. 440, figs. 20a, b, 1859.

Orthis ignicula RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 369, 1905; Ann. Carnegie Mus., vol. 7, No. 2, p. 236, figs. 10, 11, 1911.

Hesperorthis ignicula (Raymond) TWENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 46, pl. 7, figs. 3-5, 1938.

This species is generally fairly small for the genus, but the outlines and profile are typical. The ornamentation consists of high, narrowly rounded costae that appear in 2 generations, one at the beak and the other slightly anterior to it. Nevertheless, the costae are of about uniform size along the margins. The interspaces show a single costella. No pseudodeltidium was seen at the apex of the delthyrium and none was reported by Raymond. The cardinalia of the brachial valve are like those of *Hesperorthis*. Thus the entire expression of this species, internal and external, is that of *Hesperorthis*, and this is perhaps the earliest species of the genus.

Types.—Lectotype: Carnegie Mus. 5453; paratype: Carnegie Mus. 5527; figured hypotypes: 109925a, b.

Horizon and locality.—Valcour formation in New York: Cystid Point, Valcour Island, Plattsburg (15') Quadrangle; on New York Highway 22, about 1 mile southeast of Beekmantown, Rouses Point (15') Quadrangle.

HESPERORTHIS LONGIROSTRIS Cooper, new species

Plate 52, A, figures 1-7

Hesperorthis cf. *H. tricenaria* (Conrad) BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 41, pl. 73, figs. 11, 12, 15 (not figs. 13, 14—*Dinorthis* sp.), 1942.

Shell of about usual size for the genus, slightly wider than long; hinge slightly narrower than the greatest shell width which is at about the middle. Cardinal extremities varying from a right angle to slightly obtuse. Anterior commissure rectimarginate to very slightly sulcate. Lateral margins varying from nearly straight to very gently rounded; anterior margin fairly strongly rounded. Surface costate, with 27 to 30 strongly rounded costae separated by interspaces slightly narrower than the costae, fine radial costellae appearing in the interspaces and on the costae but too indistinct to enumerate.

Pedicle valve with the greatest curvature in the posterior half; somewhat narrowly rounded medially in anterior profile; beak pointed, forming an angle of 100° to 110°. Umbonal region narrowly rounded with steep umbonal slopes. Median region moderately swollen with steep slopes to the anterior and lateral

margins. Interarea long, steeply apsacline, slightly curved. Pseudodeltidium present but a mere vestige. Interior with short, receding dental plates; teeth small; lateral plates narrow; vascula media convergent medially, not strongly developed.

Brachial valve slightly convex in lateral profile but perceptibly convex in anterior profile. Sulcus originating at the umbo, widening rapidly anteriorly but only slightly perceptible at the anterior margin. Flanks bounding the sulcus slightly convex; cardinal extremities gently deflected toward the pedicle valve. Interarea fairly long, anacline. Interior with stout median ridge, moderately thickened notothyrial platform, and moderately long brachioophores.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.0 | 10.7 | 14.4 | 13.8 | 7.5 |
| Paratype (98180e) | 10.2 | 9.4 | 13.2 | 13.0 | 6.0 |
| " (109934d) | 14.4 | 12.0 ? | 16.7 | 15.1 | 6.5 |

Types.—Holotype: 98180a; figured paratypes: 116920e, 109934i; unfigured paratypes: 98180b-e, 116920a-d,f, 109934a-h,j-t.

Horizon and locality.—Whistle Creek formation in Virginia: 1½ miles northwest of Lexington on Whistle Creek and on U. S. Highway 60, 100 yards southeast of Whistle Creek, Lexington (15') Quadrangle; Virginia Highway 602, 5½ miles S. 82° W. of Middlebrook, Augusta County.

Ellett formation in Virginia: Ellett and Lusters Gate, Blacksburg (15') Quadrangle.

Lincolnshire formation in Tennessee: ½ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; Evans Ferry. In Virginia: At Marcem Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle.

Discussion.—This species resembles *H. australis* but generally in its adult state is somewhat larger. The brachial valve is generally flat or convex, seldom concave in the adult. The most distinguishing feature is the interarea of *H. longirostris* which is much longer than that of *H. australis*. The greater length of the interarea makes *H. longirostris* considerably thicker in the posterior half than is the stratigraphically higher species.

Although the outline and profile of *H. longirostris* approach those of *H. sulcata*, the two species may be distinguished by the more prominent sulcus of the latter and the longer interarea of *H. longirostris*.

HESPERORTHIS MATUTINA Cooper, new species

Plate 54, A, figures 1-4

Shell of about medium size for the genus, wider than long, with nearly straight lateral margins and cardinal extremities approximating a right angle. Front margin broadly rounded. Surface marked by 25 to 27 elevated, rounded costae separated by interspaces about half the width of the costae. Fine radial costellae appearing indistinctly between the costae.

Pedicle lateral profile with greatest convexity in the posterior half; anterior

profile broadly convex. Umbonal region convex; median portion of valve slightly swollen. Anterior and lateral slopes gently convex, the lateral slopes the steeper. Interarea strongly apsacine, nearly flat; delthyrium without a pseudodeltidium as far as can be observed. Interior with short, receding dental plates; muscle area as usual in the genus.

Brachial valve with posterior half very slightly convex but the anterior half perceptibly concave; median region slightly depressed by a shallow and wide sulcus originating at the umbo. Flanks bounding sulcus very slightly convex; cardinal extremities slightly deflected toward the pedicle valve. Interarea short, anacine. Interior with short but stout brachiophores which are triangular in section because they have a keel along the outer face. Notothyrial platform not greatly thickened; cardinal process slender but the thickened base bearing a longitudinal slit.

Measurements in mm.—

| | Length | Width | Hinge width |
|--|--------|-------|-------------|
| Holotype (pedicle valve)..... | 12.5 | 15.5 | 15.2 |
| Paratype (brachial valve 109975a)..... | 9.7 | 12.0 | 13.5 |

Types.—Holotype: 109975b; figured paratypes: 109975a,c,e; unfigured paratypes: 109975d,f-i.

Horizon and locality.—Tulip Creek formation in Oklahoma: West Spring Creek, northeast corner sec. 1, T. 2 S., R. 2 W., 3 miles east of Pooleville; along an east-west road 2 miles southwest of Nebo, Murray County.

Discussion.—The closest relative of this species is *H. ignicula* (Raymond) from the Valcour limestone of the Chazy group of New York. In the Oklahoma species the costae are wider and separated by narrower striae, the pedicle beak is less incurved, and the same valve is less convex; inside the brachial valve the notothyrial platform is smaller and more thickened and the cardinal process stouter.

HESPERORTHIS MULTICOSTATA Cooper, new species

Plate 51, C, figures 14-18

About medium size for the genus, slightly wider than long. Hinge about equal in width to the midwidth of the valves. Lateral margins nearly straight; antero-lateral margins gently curved; anterior margin somewhat narrowly rounded. Anterior commissure gently sulcate. Apical angle 130° . Surface ornamented by 38 narrowly rounded costae separated by spaces narrower than the costae.

Pedicle valve unevenly convex in profile; the greatest convexity located near the middle. Umbonal region flattened in lateral profile. Anterior profile narrowly convex with the flanks forming an angle of 110° . Umbonal region subcarinate, the folding prominent at the middle but only slightly defined at the front. Lateral slopes steep and flat. Interarea strongly apsacine, forming an angle with the lateral commissure slightly more than a right angle; very slightly curved. Beak slightly incurved.

Brachial valve gently convex in lateral profile; strongly indented medially in

anterior profile. Median sulcus deepest in the posterior half, becoming shallower and wider anteriorly and occupying about one-fourth the width at the front. Flanks bounding sulcus strongly folded for the genus. Posterolateral slopes concave, gentle.

Measurements in mm.—Holotype, length 14.1, brachial length 12.0, width 15.7, hinge width 14.0, thickness 6.8.

Types.—Holotype: 109986.

Horizon and locality.—Lincolnshire formation in Tennessee: Evans Ferry, U. S. Highway 25E, about 1 mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—This species is distinguished by the numerous closely crowded costae, the deep sulcus, and the strongly carinate pedicle valve. It is somewhat similar to *H. biconvexa* but is more carinate, has a deeper sulcus and more closely crowded costae.

HESPERORTHIS QUADRATA Cooper, new species

Plate 50, K, figures 47-54

Shell of about medium size for the genus, length and width about equal; hinge forming the greatest width; cardinal extremities slightly auriculate; sides nearly straight; anterior commissure sulcate; anterior margin narrowly rounded; surface marked by 28 to 32 rounded costae separated by spaces narrower than the costae.

Pedicle valve unevenly convex in lateral profile, the posterior half having the greater convexity; anterior profile narrowly convex and with steep lateral slopes. Umbonal region swollen, the swelling continued anteriorly along the median portion as a low fold; cardinal extremities not flattened but forming a part of the steep and long umbonal slope. Interarea long, slightly curved, strongly apsacline. Pseudodeltidium moderately long. Interior with short, receding dental plates.

Brachial valve gently concave in lateral and anterior profiles; umbo sulcate, the sulcus deepening and widening anteriorly to the front margin where it is moderately deep and somewhat V-shaped; 5 or 6 costae occupy the sulcus; flanks bounding sulcus flattened; posterolateral extremities very slightly deflected in the direction of the pedicle valve. Interior with the usual features of the genus.

Measurements in mm.—Holotype, length 12.9, brachial length 10.0, width 12.7, hinge width 13.3, thickness 6.4.

Type.—Holotype: 116921.

Horizon and locality.—Lebanon formation in Tennessee: Cut on U. S. Highway 241, 2.1 miles north of the Bedford-Rutherford County line in Rutherford County; Lebanon; cut and quarry on U. S. Highway 41, 12 miles southeast of Murfreesboro; south side of U. S. Highway 70S, $\frac{1}{2}$ to $\frac{3}{4}$ mile east of Readyville; Columbia; south of Aspen Hill; Lavergne; near Prospect; Tennessee Highway 16, 5.1 miles north-northwest of Shelbyville; 13 miles west of Spring City, Sequatchie Valley; Shelbyville; U. S. Highway 70S, $\frac{1}{2}$ mile east of Rutherford-

Cannon County line, Cannon County; U. S. Highway 70N, opposite Fairview Service Station, $\frac{1}{2}$ mile west of Rome, Smith County.

Lebanon formation in Georgia: Beside the road 0.1 to 0.2 mile south of the quarry, $1\frac{3}{4}$ miles south-southeast of Cove Church, 5 miles south of Chickamauga, Kensington (T.V.A. 106-SE) Quadrangle.

Discussion.—This species is characterized by its parallel sides and small ears and the deeply sulcate anterior commissure. In the latter respect it reminds one of *H. sulcata*, but the commissure of the Lebanon form is deeper than that of the Oklahoma species and the outline is very different. The Lebanon species is suggestive of *H. colei* but has a deeper sulcus which reaches the anterior margin whereas this feature of *H. colei* does not significantly affect the margin.

HESPERORTHIS SULCATA Cooper, new species

Plate 52, D, figures 22-37

Orthis tricenaria DECKER (not Conrad), Oklahoma Geol. Surv. Bull. 55, pl. 13, fig. F, 1931.

Shell of about medium size for the genus, length and width nearly equal in the adult but with the width exceeding the length in the young. Hinge forming the greatest shell width in young specimens but equal to or slightly less than the greatest shell width in adults. Greatest shell width of adults variable, located between hinge extremity and middle. Cardinal extremities slightly auriculate in the young, nearly a right angle in adults. Lateral margins nearly straight or very gently convex; front margin broadly rounded. Anterior commissure varying from strongly to gently sulcate. Valves ornamented by 28 to 30 broadly rounded to subangular costae separated by striae narrower than the costae. One or more fine radial lines occupying the striae between the costae, the line at the base of the stria being the larger.

Pedicle valve moderately and evenly convex in lateral profile; broadly and fairly strongly convex in anterior profile. Median region somewhat swollen from umbo to anterior margin but well rounded and not subcarinate. Lateral slopes long and steep; anterior slope long but not as steep as the lateral slopes. Interarea long, strongly apsacline, curved. Beak incurved; delthyrium long and narrow; pseudodeltidium short. Teeth small, dental plates short and receding. Delthyrial cavity deep and narrow; muscle area small. Vascula media narrow, deeply impressed.

Brachial valve gently concave in lateral profile and medially sulcate with flattened flanks in anterior profile. Beak prominent, somewhat elevated. Interarea moderately long, strongly anacline. Sulcus deep, originating at the beak and widening to the anterior margin where it occupies about one-third the width. Flanks bounding sulcus narrow, very gently convex; posterolateral areas flattened; cardinal extremities deflected toward the pedicle valve. Interior with shallow notothyrial cavity bounded by broad and long brachiophores. Median ridge short and low. Sockets narrow, deep. Cardinal process not strongly thickened.

Measurements.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.8 | 11.7 | 15.3 | 14.1 | 6.7 |
| Paratype (109992d) .. | 13.5 | 10.9 | 14.0 | 12.4 | 6.0 |
| " (109994c) .. | 10.5 | 8.7 | 10.3 | 11.3 | 5.7 |
| " (109994b) .. | 10.4 | 8.7 | 11.7 | 11.8 | 5.0 |
| " (109988a) .. | 14.3 | 11.4 | 14.7 | 14.4 | 6.9 |
| " (109987d) .. | 16.2 | 13.3 | 17.2 | 15.6 | 7.0 |
| " (109987c) .. | 14.0 | 11.1 | 15.8 | 15.2 | 6.5 |

Types.—Holotype: 109987b; figured paratypes: 109987a,d, 109992e, 109994b; unfigured paratypes: 109987c,e,f, 109988a-f, 109992a-d, 109994a,c-h, 116922.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E.; on a branch of Hickory Creek, NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., Criner Hills, Carter County. Upper Bromide formation in Oklahoma: Just west of the road on the Russell Ranch, SE $\frac{1}{4}$ sec. 3, T. 2 S., R. 3 E., Murray County.

Discussion.—This species is characterized by having its length and width nearly equal, broad costae, and deep brachial sulcus. It is closest to *H. australis* but differs in its more quadrate outline and the greater development of the sulcus.

HESPERORTHIS TENUICOSTATA Cooper, new species

Plate 54, E, figures 22-40; plate 82, B, figures 7-11

Shell of about medium size for the genus, a little wider than long. Width of hinge about equal to width of valve at middle or somewhat less. Lateral margins very slightly to moderately curved; front margin broadly rounded. Anterior commissure slightly sulcate. Apical angle about 110°. Surface marked by about 29 direct, elevated, and narrowly rounded costae with interspaces about as wide as the width of a costa.

Pedicle valve moderately convex with the greatest convexity in the posterior half; anterior profile strongly convex. Median portion swollen; flanks gently convex and moderately steep. Interarea gently curved, strongly apsacline. Beak a little incurved. Interior with small elongate muscle area.

Brachial valve slightly convex in lateral profile; slightly indented medially in anterior profile. Sulcus narrow, very shallow. Flanks bounding sulcus very slightly swollen. Posterolateral extremities slightly depressed. Notothyrial cavity shallow; brachiophores long.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.8 | 9.1 | 11.2 | 9.8 | 5.0 |
| Paratype (109973a) .. | 11.5 | 9.5 | 12.5 | 10.6 | 5.9 |

Types.—Holotype: 116924; figured paratypes: 109970a, 109973a, 116923; unfigured paratypes: 109970b-d, 109973b-e.

Horizon and locality.—Lenoir formation (ss.) in Tennessee: At Sweetwater, Sweetwater (T.V.A. 131-SW) Quadrangle; quarry on north side U. S. Highway 11, $\frac{1}{2}$ mile south of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle. Shale streak in granular beds below Mosheim limestone: Behind Quaker Church, north corner of Friendsville, Concord (T.V.A. 138-SW) Quadrangle. In Virginia: Along the road on North Fork, 3 miles south-southeast of North Fork, Christiansburg (30') Quadrangle.

Discussion.—This species suggests *H. australis* but differs in having a narrower hinge, more convex pedicle valve, a more convex brachial valve, and more curved palintrope. It differs from *H. longirostra* in having a shorter palintrope and more rounded outline.

HESPERORTHIS TRICENARIA (Conrad)

Plate 52, C, figures 16-21; plate 54, B, figures 5-10

Orthis tricenaria CONRAD, Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 333, 1843.—BASSLER, U. S. Nat. Mus. Bull. 92, p. 897, 1915.

Hesperorthis tricenaria (Conrad) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 86, 1932.

Orthis disparilis CONRAD, Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 333, 1843.

Large for the genus; slightly wider than long; cardinal extremities slightly obtuse or approximately a right angle, occasionally auriculate; sides nearly straight to gently rounded; anterior margin broadly rounded; anterior commissure rectimarginate to faintly sulcate. Surface marked by 32 narrowly rounded and elevated costae; interspaces marked by a single costella in the trough.

Pedicle valve strongly and evenly convex in lateral profile; anterior profile strongly convex with a tendency to subcarination in the median region; lateral slopes long and steep. Beak erect and elongated; umbo full; fold indistinct but indicated by a single median costa more elevated than those surrounding it; median region swollen; posterolateral slopes steep. Interarea long, slightly curved, strongly apsacline; pseudodeltidium small.

Brachial valve nearly flat to gently concave in lateral profile; anterior profile gently concave; umbo concave, marked by a shallow, narrow sulcus that extends anterior to the front margin; sulcus inconspicuous; flanks bounding sulcus flat to slightly concave; cardinal extremities deflected slightly toward the pedicle valve. Interarea long, strongly anacline.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (24752a)..... | 19.6 | 15.7 | 21.2 | 20.3 | 9.3 |
| " (84000)..... | 20.1 | 15.9 | 22.3 | 22.5 | 9.0 |
| " (109982a)..... | 18.4 | ? | 21.0 | 20.7 | 6.9 |
| " (109982b)..... | ? | 15.9 | 21.2 | 20.5 | 2.4 |

Types.—Holotype of *Orthis disparilis*: A.M.N.H. 911/1. Figured hypotypes of *H. tricenaria*: 24752a, 109982a; measured hypotypes: 84000, 109982b.

Horizon and locality.—Decorah formation (Guttenberg member) in Wisconsin: Mineral Point; 0.1 mile south of the Little Platte River on Wisconsin Highway 81, 2 miles northwest of Platteville, Mineral Point (30') Quadrangle; 3 miles northwest of Platteville, Lancaster (30') Quadrangle.

Same formation in Illinois: At Rocton.

Lower Trenton limestone in New York: At Middleville.

Barnhart formation in Missouri: On the old road 1 mile northwest of Chicago Summer Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E., Weingarten (15') Quadrangle; at Koch Valley School on U. S. Highway 61, NE. cor. SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T. 41 N., R. 7 E., 2 miles south of Barnhart, Kimmswick (15') Quadrangle; on U. S. Highway 61, 0.1 mile south of Salt River, north of New London, Ralls County.

Auburn chert in Missouri: $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle.

Rockland formation in Ottawa, Canada: At Paquette Rapids.

Curdsville formation in Kentucky and Tennessee.

Discussion.—This species is characterized by its large size, being one of the largest members of the genus to occur in the Middle Ordovician. It is characterized, besides its size, by its nearly parallel sides, shallow, narrow sulcus, and indistinct pedicle fold. Although the type specimen is lost, it is possible to identify the species in the Middle Ordovician sequence of southwestern Wisconsin by its reported large size. The horizon of this large form is the lower part of the Guttenberg above the thin band of blue clay so conspicuous in this part of Wisconsin. The species is also conspecific with the abundant large *Hesperorthis* of the Curdsville in Kentucky and its equivalents in southwestern Virginia and eastern Tennessee. The species is also abundant in the upper part of the Platin limestone group and the so-called Decorah of eastern Missouri.

Hesperorthis disparilis (Conrad) is a small species that has for some years been placed in the synonymy of *H. tricenaria*. This seems to be the correct place for the species because the type specimen appears to be a young form.

HESPERORTHIS VIRGINIENSIS Cooper

Plate 51, D, figures 19, 20; plate 82, G, figures 28-32

Shell of about medium size for the genus, length and width about equal; cardinal extremities approximately a right angle, hinge slightly narrower than the greatest shell width at about the middle; anterior commissure gently sulcate; sides nearly straight to slightly rounded; anterior margin strongly rounded; surface marked by 30 rounded costae.

Pedicle valve gently convex in lateral profile with the greatest convexity in the posterior half; anterior profile narrowly convex and with long, steep slopes; umbo narrowly swollen, the swelling occupying the median region from the beak to the margin, forming a poorly defined fold; lateral slopes steep. Interarea strongly apsacline to nearly catacline.

Brachial valve almost plane in lateral profile; gently concave in anterior profile; umbonal region sulcate, the sulcus deepening and widening anteriorly to

the front margin where the sulcus occupies nearly half the width; sides bounding sulcus nearly flat; posterolateral extremities deflected slightly toward the pedicle valve.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.9+ | 12.0 | 14.8 | 13.9 | 6.6 |
| Paratype (97598).... | 15.9 | 13.2 | 16.5 | 14.2 | 7.0+ |

Types.—Holotype: 116927a; figured paratype: 97598; unfigured paratype: 116927b.

Horizon and locality.—Oranda formation in Virginia: $\frac{1}{4}$ mile north-northwest of Green Mount Church; Broadway (15') Quadrangle.

Discussion.—This species is characterized by its slender form, subcircular outline and steeply apsacline pedicle interarea. It is less convex, more slender in outline, and somewhat more circular in outline than *H. australis* to which it has some resemblance.

HESPERORTHIS sp. 1

Plate 54, F, figure 41

Represented by two specimens from the Botetourt formation in Virginia exposed at the junction of Virginia Highways 311 and 114, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle. One specimen is crushed but shows both valves. The exterior is marked by about 25 narrowly rounded costae. The brachial sulcus is narrow, shallow, and inconspicuous. Scarcely any trace of folding is exhibited on the pedicle valve. The interarea is curved, apsacline, but not strongly so.

The second specimen is a cast of the pedicle interior showing strong dental plates but a small muscle field. The lack of marked folding sets this shell apart from all others described herein, but the specimens are too poor for further elaboration.

Figured specimen.—109972.

HESPERORTHIS sp. 2

Plate 50, C, figures 8-13

A very well preserved specimen of *Hesperorthis* was taken near the middle of the Edinburg formation (*Nidulites* zone) in Virginia, along Tumbling Run about $1\frac{1}{2}$ miles southwest of Strasburg, Strasburg (15') Quadrangle. It closely resembles the type specimen of *H. disparilis* now assigned to *H. tricenaria*, but it differs from that species in details of the ornamentation, showing it to be a different species. The specimen is probably the young of a *Hesperorthis* which has not yet been seen in adult form.

Figured specimen.—116926.

Subfamily GLYPTORTHINAE Schuchert and Cooper, 1931

Specialized Hesperorthidae with interior characters similar to *Hesperorthis* but with an imbricated external surface. Pseudodeltidium and chilidium usually absent but small apical (pedicle?) plate present.

Genus GLYPTORTHIS Foerste, 1914

Glyptorthis FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 17, p. 258, 1914.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 89, 1932.

GLYPTORTHIS ALTA Cooper, new species

Plate 44, A, figures 1-5

Shell of moderate size for the genus, hemipyramidal in outline; biconvex; valves of unequal depth. Cardinal extremities obtuse. Lateral margins gently rounded; front margin broadly rounded. Anterior commissure faintly uniplicate. Surface multicostellate, with 8 costellae occupying a space of 5 mm. at the front. Costellae increasing by intercalation.

Pedicle valve hemipyramidal; unequally convex in lateral profile, with the umbonal region moderately convex, the midportion of the profile flat and the anterior quarter gently convex. Lateral slopes steep. A narrow, shallow sulcus extends from the umbo to the front margin where it forms a slight tongue. Interarea long, nearly flat, strongly apsacline. Delthyrium long and narrow. Dental plates short, receding; anterior margin of muscle field thickened.

Brachial valve moderately convex in both profiles, somewhat swollen and with moderately steep lateral slopes. Sulcus present on umbo but obsolete toward the front where a narrow fold is barely discernible. Interarea long, deeply concave, orthocline in position. Cardinalia ponderous; median ridge slender.

Measurements in mm.—Holotype, length 11.0, brachial length 11.0, width 13.5, hinge width 11.5, thickness 10.0.

Type.—Holotype: 110008.

Horizon and locality.—Kimmswick formation in Missouri: Goetz Quarry, Jefferson County.

Discussion.—This species suggests *G. obesa* in its form and ornamentation, but the interarea of the pedicle valve is much longer and more strongly inclined. The specimen referred by Bradley (Contr. Walker Mus., Univ. Chicago, vol. 2, No. 6, p. 227, pl. 23, figs. 13-15, 1930) to *Clitambonites diversus* may belong to this species. No cardinal view of that specimen is given which would reveal the presence or absence of a pseudodeltidium, but the profiles suggest this new *Glyptorthis*.

GLYPTORTHIS ASSIMILIS Cooper, new species

Plate 45, C, figures 15-35; plate 49, F, figures 27-32

Shell of medium to large size for the genus, wider than long in the young but with the length and width about equal in adults. Hinge forming the widest part in the young, becoming narrower in large specimens. Valves subequal in depth,

the pedicle valve having a slightly greater depth. Anterior commissure rectimarginate to faintly sulcate. Surface marked by high, narrowly rounded to angular costellae, 6 in the space of 5 mm. at the front of a large valve. Imbrications distant, about 10 in 5 mm.

Pedicle valve moderately convex in lateral profile with the greatest convexity just anterior to the flattened umbo. Anterior profile moderately convex. Mid-region moderately inflated. Slopes to lateral margins fairly steep and flat; anterior slope long and steep. Interarea moderately long, only slightly curved, strongly apsacline. Beak prominent, slightly incurved. Teeth small, dental plates short, receding. Muscle field large, extending to middle of valve.

Brachial valve moderately convex in lateral profile with the greatest convexity in the midregion. Anterior profile gently convex. Sulcus shallow, occupying a little more than one-third the width at the front margin. Sulcus occupied by 2 costellae at the umbo which increase by intercalation to 6 or more at the anterior margin. Second generation costellae intercalated on the inside of the primary 2; next generation intercalated on the outside of the primary 2. Umbo gently convex; interarea long, a little curved; beak only slightly incurved. Notothyrial cavity small and shallow; brachiophores short; cardinal process thin; median ridge low, extending anterior to middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.7 | 12.5 | 15.2 | 14.1 | 8.2 |
| Paratype (110012a) | 11.7 | 10.8 | 12.6 | 9.6 | 7.6 |
| “ (pedicle valve 110012c) ... | 13.8 | ? | 14.2 | 10.2 | 4.3 |
| “ (“ “ 110013a) ... | 13.5 | ? | 14.0 | 11.6 | ? |
| “ (brachial valve 110013f) .. | ? | 12.8 | 15.4 | 13.8 | ? |
| “ (110013d) | ? | 11.0 | 13.9 | 11.8 | ? |

Types.—Holotype: 110013j; figured paratypes: 110012c, 110013b-d,f,g, 116928c,f-i; unfigured paratypes: 110012a,b,d-f, 110013a,e,h,i, 116928a,b,d,e.

Horizon and locality.—Ridley formation (lower third) in Tennessee: At Murfreesboro; east side Marshall Knobs, 5 miles south of Murfreesboro, Murfreesboro (15') Quadrangle.

Discussion.—This species is characterized by the strong convexity of both valves, lack of perceptible fold or sulcus on the pedicle valve, and the fairly deep and prominent brachial sulcus. The latter feature is a variable one, but in general the sulcus is deepest between the two primary median ribs but may be defined on each side of them as well.

Glyptorthis assimilis is most like *G. bellatula* from the Chatham Hill formation north of Marion, Va., but differs in having a more convex pedicle valve particularly in the median and posterior parts, in having a prominent pedicle umbo and beak, and a more strongly incurved beak. The pedicle muscle area of the Tennessee species is in general somewhat larger than that of *G. bellatula*. The brachial valve of *G. assimilis* is less convex than that of *G. bellatula*, and the sulcus is less prominent. The ornamentation of the two species is different, that of *G. as-*

similis tending to have prominent differentiation of the primary and postprimary elements, whereas in *G. bellatula* the costellae are less strongly differentiated.

GLYPTORTHIS BELLARUGOSA (Conrad)

Plate 48, C, figures 12-18

Orthis bellarugosa CONRAD, Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 333, 1843.—HALL, Pal. New York, vol. 1, p. 118, pl. 32, fig. 3, 1847.—BASSLER, U. S. Nat. Mus. Bull. 92, p. 591, 1915.

Conrad's type lot consists of two specimens, one small complete one and a larger pedicle valve. The latter preserves the interior well, but the external ornamentation is badly worn. In his description Conrad gives the length of the species as "less than half an inch." It is best then to select the smaller specimen as the holotype even though the species attains a greater length than half an inch. The type specimen may be characterized as follows:

Outline quadrate, with gently convex lateral margins but nearly straight anterior margin. Cardinal extremities slightly greater than a right angle; anterior commissure rectimarginate; valves nearly equal in depth, the pedicle valve having a slightly greater depth; surface multicostellate with about 57 costellae appearing in 3 generations. Median costella of pedicle valve slightly larger than surrounding ones and extending directly from beak to margin. Imbricating concentric ornamentation closely spaced, about 6 imbrications in 2 mm., forming rounded, short, blunt spines open anteriorly and at their extremity.

Pedicle valve moderately convex in lateral profile with the greatest convexity located slightly anterior to the umbo. Front third slightly flattened; fold not well defined but median costella elevated throughout its length, and at anterior third a costella is intercalated on each side to form a median fascicle that serves as a fold. Median region somewhat swollen; lateral slopes even and steep.

Brachial valve with sulcus originating at beak and extending to anterior margin, narrow and shallow throughout its length. Sulcus marked by implantation of a costella on each side; additional costellae implanted on inside and outside of these 2 slightly posterior to the middle. Tertiary intercalation of costellae occurring anteriorly and bringing total number in sulcus to 9. Flanks bounding sulcus gently swollen; slopes to cardinal extremities gentle and low.

Measurements in mm.—Lectotype, length 11.0, brachial length 10.0, width 12.0, hinge width 9.5, thickness 5.7.

Types.—Lectotype: A.M.N.H. $\frac{909}{1}$; paratype: A.M.N.H. (not numbered).

Horizon and locality (of lectotype).—Decorah formation (Ion member ?) in Wisconsin: At Mineral Point, Mineral Point (30') Quadrangle.

Discussion.—The type specimen of *G. bellarugosa* is characterized by its quadrate outline and its fairly fine costellae. No other specimens in the National Museum collections are quite like this one. For that reason it is difficult to assign the correct part of the Decorah shale from which the species comes. *Glyptorthis bellarugosa* suggests *G. costellata* from the Bromide formation

(Pooleville member) of Oklahoma, but it is squarer and the ornamentation is finer. Furthermore, the sulcus of the Oklahoma species is wider and deeper than that of the Wisconsin form.

GLYPTORTHIS BELLATULA Cooper, new species

Plate 47, A, figures 1-8

Shell of about medium size for the genus, length and width about equal; hinge slightly narrower than the greatest shell width which is located slightly anterior to the middle. Cardinal extremities obtuse; lateral margins varying from nearly straight to sloping anterolaterally; anterior margin broadly rounded. Anterior commissure rectimarginate. Surface marked by subangular, fairly broad costellae separated by spaces about equal in width to the width of the costellae. Posterior half of shells marked chiefly by primary costellae, the secondary costellae appearing in the front half, one in each primary stria. Lamellae strong, distant, 2 or 3 in a millimeter measured near the middle of the valve.

Pedicle valve with lateral profile gently convex and with the greatest convexity located in the umbonal region; anterior profile broadly convex. Umbonal region subcarinate becoming flattened anteriorly to merge in the general convexity of the valve. Anterior slope long, moderately steep; lateral slopes convex, fairly steep. Interarea long, strongly apsacline. Teeth small, with deep fossettes. Dental plates short and receding; muscular area not extending to the middle of the valve, not greatly thickened. Vascula media distinct, short.

Brachial valve evenly convex in lateral profile and with the maximum convexity at about the middle; anterior profile broadly convex, slightly depressed medially. Umbonal region moderately convex; sulcus originating just anterior to the posterior margin, narrow and shallow, extending to the anterior margin or dissolving into the general convexity of the valve just posterior to the front margin. Flanks moderately convex with moderately steep slopes to the cardinal extremities but shorter and more gentle slopes to the anterolateral margins. Interarea short, anacline; median ridge carinate, extending slightly anterior to the middle. Brachiophores and cardinal process usual for the genus.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 12.3 | 13.7 | 11.9 | 4.3 |
| Paratype (brachial valve 110015e).... | 10.7 | 12.6 | 10.0 | 2.8 |
| " (110015c) | 8.9 | 11.7 | ? | ? |

Types.—Holotype: 110015a; figured paratypes: 110015d-h; unfigured paratypes: 110015b,c.

Horizon and locality.—Chatham Hill formation in Virginia: Route 113 (Marion-Chatham Hill road), 6 miles north of Marion, Chatham Hill (T.V.A. 218-NE) Quadrangle.

Discussion.—See *Glyptorthis assimilis*.

GLYPTORTHIS CONCINNULA Cooper, new species

Plate 43, F, figures 22-43

Small to medium-sized for the genus, wider than long, with the hinge forming the greatest shell width or so narrowed as to be less than the width near the middle. Lateral margins ranging from straight and sloping medianly to gently convex; anterior margin straight or slightly curved. Surface multicostellate, the costellae elevated and subangular and separated by spaces as wide or wider than the costellae. Three generations of costellae may be counted: a set originating at the beaks, a secondary set, few in number, intercalated near the middle and a ternary set appearing a short distance posterior to the margin. From 6 to 9 costellae appear in 5 mm. at the front margin depending on the amount of anterior intercalation. From 20 to 36 costellae may be counted on a valve. About 3 imbricating lamellae in the space of 1 mm. near the middle.

Pedicle valve in lateral profile with maximum convexity in the posterior half; in anterior profile broadly convex with moderately sloping sides. Umbo full, this fullness extended for the median length as an indistinct fold. Lateral slopes long but only moderately steep as most of the fullness is concentrated in the median area. Beak slightly incurved; interarea nearly flat, short. Delthyrium narrow. Interior with short, thick dental plates; moderately deep delthyrial cavity; muscle field heart-shaped with adductor field slightly elevated, large diductor impressions but small adjustor scars.

Brachial valve most convex in the posterior half in lateral profile but broadly and gently convex and with the median part sulcate in anterior profile. Sulcus originating at the umbo, prominent, widening and deepening anteriorly, variable in depth and width. Sulcus with 2 costellae on the umbo, bifurcating in a short distance to produce 4, and this number augmented by intercalations of the ternary set near the front margin. Flanks moderately convex with short but fairly steep umbonal slopes and with lateral slopes becoming less steep anteriorly. Interarea short. Interior of brachial valve with short, stout brachiophores, prominent median ridge and large adductor field. The anterior adductor scars are each divisible into 2 impressions; the posterior scars small. Pallial marks not well preserved in either valve.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 7.5 | 6.2 | 8.4 | 7.1 | 4.8 |
| Paratype (110025a).... | 8.3 | 7.6 | 10.1 | 9.5 | 5.4 |
| " (110026)..... | 7.2 | 6.9 | 8.7 | 7.2 | 4.6 |
| " (116931b)..... | 6.2 | 5.5 | 7.4 | 6.1 | 3.7 |
| " (110035a)..... | 8.3 | 7.8 | 10.4 | 9.6 | 4.4 |
| " (110027a)..... | 7.6 | 6.8 | 8.0 | 7.2 | 5.2 |

Types.—Holotype: 116931a; figured paratypes: 110025a, 110027a,b, 110028a,b, 110034a,b,e,g, 110035a; unfigured paratypes: 110026, 110028c-e, 110034c,d,f; 116931b.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile northeast of

Pelham, and 2 miles north of Pelham, Bessemer Iron District (15') Quadrangle. Intersection of the Bailey Gap road with the main Cahaba Valley road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Basal Athens formation in Tennessee: Along the road 2 $\frac{1}{2}$ miles south-south-east of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle; 600 feet S. 40° E. of the railroad and highway crossing 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-NE) Quadrangle.

Arline formation in Tennessee: Knoxville; southeast edge of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Arline formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This is a small variable species but the majority of specimens are wider than long with moderately convex valves, a pedicle valve with considerable fullness longitudinally in the median area and a fairly wide and deep sulcus in the brachial valve. It is not quite like any other species described but approaches *G. sulcata* from which it differs in its more rectangular outline, smaller size, less elongated palintrope of the pedicle valve, and shallower brachial valve.

GLYPTORTHIS COSTELLATA Cooper, new species

Plate 43, C, figure 8; plate 44, D, figures 20-37

Glyptorthis cf. *bellarugosa* SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, pl. 6, fig. 12, 1932.

Shell of about medium size for the genus, subquadrate in outline, and with the width slightly greater than the length. Cardinal extremities forming a right angle. Lateral margin straight to gently curved; anterolateral margins rounded; anterior margin slightly rounded to straight. Valves nearly equal in convexity. Anterior commissure rectimarginate to slightly sulcate. Surface covered by about 47 thin, angular to narrowly rounded costellae, of which about 9 or 10 occupy 5 mm. at the front. Imbrications distant at the posterior but becoming crowded toward the front of the valves, 2 to 3 in 1 mm.

Pedicle valve only moderately convex in both profiles, having the greater convexity a little posterior to the middle. Midregion inflated; lateral slopes moderately steep; anterior slope gentle. Interarea moderately long; slightly curved; apsacline.

Brachial valve gently and evenly convex with the greatest convexity at about the middle. Sulcus prominent, widening from the umbo to occupy more than half the width at the front margin where as many as 13 costellae may occupy it. Flanks bounding sulcus moderately swollen. Slopes to cardinal extremities gently concave and moderately steep. Interarea moderately long; slightly apsacline. Beak slightly incurved.

Measurements in mm.—

| | Length | Dorsal length | Width | Hinge width | Thickness |
|-----------------------|--------|---------------|-------|-------------|-----------|
| Holotype | 12.1 | 11.4 | 13.8 | 11.2 | 6.2 |
| Paratype (110045a) .. | 10.5 | 10.0 | 11.3 | 11.0 | 5.5 |
| " (110040a) .. | 9.3 | 8.8 | 10.8 | 8.8 | 5.0 |
| " (110040b) .. | 8.1 | 8.0 | 9.6 | 8.5 | 4.5 |
| " (110059a) .. | 12.2 | 11.3 | 13.8 | 10.4 | 6.8 |
| " (110059c) .. | 12.8 | 11.6 | 14.6 | 12.7 | 7.0 |

Types.—Holotype: 110052a; figured paratypes: 110038a, 110040a,b, 110052b, 110059a,b; unfigured paratypes: 110038b-d, 110040c-d, 110045a, 110059c.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: On a branch of Hickory Creek, NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., east side of Criner Hills; Rock Crossing of Hickory Creek, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 35, T. 5 S., R. 1 E.; Criner Hills, Carter County.

Discussion.—Specimens of this species from section 26 along a small branch of Hickory Creek are exceptionally well preserved and show the lamellae to perfection. Where the lamellae cross the costellae, they are pinched into narrow spinelike folds. Perfect young specimens are obtainable here and are generally transverse.

Glyptorthis costellata is suggestive of *G. sulcata* in its quadrate outline, but the valves are not so convex, the sulcus of the brachial valve is less wide and shallower, the palintrope is not so elongated, and the lamellae are coarser.

GLYPTORTHIS CRENULATA Cooper, new species

Plate 44, C, figures 11-19

Shell of about medium size for the genus, wider than long with the maximum width in the midregion; hinge narrower than the greatest shell width; cardinal extremities obtuse; sides moderately rounded; anterior margin nearly straight; anterior commissure narrowly sulcate; surface multicostellate, costellae about 2 to the millimeter at the front margin; imbrications distant, about 2 or 3 in 1 mm.

Pedicle valve gently convex in lateral profile and with the maximum convexity in the umbonal region; anterior profile with narrowly convex median region and long, flat, steep slopes to the margins. Umbonal region narrowly convex, the convexity carried to the median region where the surface becomes flattened. Median costella more elevated and stronger than those surrounding it, defining an indistinct fold.

Pedicle interior with short, receding, and flaring dental plates; muscle area deeply impressed, extending a short distance anterior to the delthyrial cavity. Vascula media and reniform ovarian impressions not strongly impressed.

Brachial valve evenly and gently convex in lateral profile with the greatest convexity at about the middle; anterior profile broadly convex, indented medianly by the sulcus; flanks bounding sulcus somewhat narrowly swollen; posterolateral slopes to the deflected cardinal extremities short and steep.

Brachial interior with moderately elevated notothyrial platform, septumlike

cardinal process; low median ridge extending to the middle, and short, stout, flaring brachiophores.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.7 | 8.6 | 11.0 | 9.5 | 5.0 |
| Paratype (116932c) .. | 10.5 | 10.1 | 12.8 | 10.9 | 4.6 |

Types.—Holotype: 116932a; figured paratypes: 110054, 116932b; unfigured paratype: 116932c.

Horizon and locality.—Bromide formation (Mountain Lake member—bed 8) in Oklahoma: From a cut on Oklahoma Highway 18, center NW $\frac{1}{4}$ sec. 11, T. 1 S., R. 3 E., 1.8 miles south of Sulphur; Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W.; Murray County.

Discussion.—This species is characterized by its subcarinate pedicle valve and the fairly deep and narrow sulcus on the brachial valve. It differs from *G. costellata* of higher Bromide beds in somewhat smaller size, less robust form, narrower profiles, and somewhat more delicate ornamentation. It is a much larger and more elongate shell than *G. uncinata* from the lower Bromide (Mountain Lake member).

GLYPTORTHIS EQUICONVEXA Cooper, new species

Plate 47, D, figures 18-30; plate 108, C, figures 15-18

Shell fairly large for the genus, subquadrate in outline but with the width slightly greater than the length; valves of nearly equal depth; anterior commissure broadly uniplicate; hinge narrower than the width at the middle; sides nearly straight; anterolateral extremities narrowly rounded; anterior margin gently rounded to somewhat truncated. Surface costellate; costellae unequal in size, appearing in 4 generations; about 5 costellae in 5 mm. at the front margin; imbrications fairly closely crowded.

Pedicle valve fairly strongly and evenly convex in lateral profile with the greatest convexity at about the middle; anterior profile swollen in the median region and with gently dipping lateral slopes. Beak incurved; umbo swollen and with steep umbonal slopes; sulcus originating about 4 mm. anterior to the beak, deepening and widening anteriorly but never attaining great depth; width of sulcus about one-third shell width. Flanks bounding sulcus gently swollen; posterolateral slopes short, moderately steep. Interarea moderately long, almost orthocline, gently curved; beak incurved; delthyrium narrow.

Brachial valve unevenly convex in lateral profile with the umbonal region strongly curved but the remainder of the valve gently convex; anterior profile swollen and fairly evenly convex; umbo strongly curved and swollen; umbo sulcate, sulcus narrow, short, becoming obsolete about 6 mm. anterior to the beak; fold low, indistinctly defined from about 6 mm. anterior to the beak to the front margin; flanks bounding fold inflated; umbonal slopes to the small depressed posterolateral areas short and steep. Beak strongly incurved; interarea short and curved.

Pedicle interior with short, receding dental plates; deep delthyrial cavity with well-impressed muscle area somewhat elevated at its anterior end; vascula media slightly divergent, short; reniform ovarian markings moderately impressed.

Brachial interior with deep notothyrial chamber, strongly elevated notothyrial platform; thin cardinal process and stout divergent brachioophores. Median ridge low, extending to the middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------------|--------|-----------------|--------|-------------|-----------|
| Holotype | 14.6 | 12.7 | 17.3 | 16.0 | 10.3 |
| Paratype (116934a). | 14.3 | 14.1 | 16.9 ? | 15.2 | 11.0 |

Types.—Holotype: 116934b; figured paratypes: 116934a,c, 116933a,b; unfigured paratype: 116934d.

Horizon and locality.—Shippensburg formation (Pinesburg member-*Echino-sphaerites* zone) in Maryland: In a cut on U. S. Highway 40, just west of Conococheague Creek at Wilson, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Botetourt formation in Virginia: On the south side of the road 0.2 mile east of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species is characterized by the obese valves and their nearly equal depth. The species is somewhat suggestive of large individuals of *G. virginica*, but that is a wider form having a sulcate pedicle valve and a low fold on the brachial valve. *Glyptorthis equiconvexa* has a subquadrate outline and thus is quite unlike *G. subcircularis* which has strongly convex valves and a robust form.

GLYPTORTHIS GLYPTA Cooper, new species

Plate 48, B, figures 7-11; plate 108, A, figures 1-5

Shell small for the genus, wider than long, with the hinge equal to, or slightly less than the greatest shell width, or forming the widest part. Cardinal extremities varying from slightly acute to slightly obtuse. Lateral margins slightly convex; anterior margin broadly rounded. Anterior commissure slightly sulcate. Surface costate, costae narrowly rounded, interspaces broad; costae numbering about 15, some costae fasciculate in front by intercalation of a generation on one or each side of the primary costa. Lamellae distant on body of shell, crowded anteriorly in old specimens.

Pedicle valve moderately convex in lateral profile; broadly convex in anterior profile. Fold generally low, not clearly perceptible in the young, most clearly defined by the strong elevation of the median costa in the posterior half; flanks descending gently to the lateral margins. Beak extending slightly posterior to the posterior margin. Interarea long, strongly apsacline. Interior with elongate, narrow diductor impressions and strongly elevated adductor track. Pallial sinuses not well defined.

Brachial valve moderately convex in lateral profile with the most strongly arched part in the posterior third; anterior profile very broadly and gently con-

vex. Posterior third somewhat swollen; sulcus originating almost at the posterior margin defined chiefly by the median depression corresponding to the median costa of the pedicle valve, extending to the anterior margin. Flanks moderately convex with gentle slopes to the posterolateral areas. Interarea anacline, fairly long. Median ridge extending slightly anterior to the middle; brachio-phores short, cardinal process moderately stout.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | ? | 6.8 | 8.6 | 7.5 | 2.5 |
| Paratype (110067f) | 5.8 | ? | 7.8 | 5.9 | 2.6 |

Types.—Holotype: 110067c; figured paratypes: 110067d-f, 116935a-c; unfigured paratypes: 110067a,b, 116935d-f.

Horizon and locality.—Effna formation, Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; opposite junction of highway with Hays Creek, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species can be recognized by its small size and the distant broad costae on the exterior. It differs from all other species herein described in the character of its ornamentation.

GLYPTORTHIS IRREGULARIS Cooper, new species

Plate 45, A, figures 1-6

Shell of about medium size for the genus, wider than long; unequally biconvex, the pedicle valve having the greater convexity; hinge narrower than the greatest shell width which is at the middle; anterior commissure rectimarginate; side gently rounded, anterior margin broadly rounded; surface multicostellate, costellae about 32 in number, crossed by strong imbricating lamellae about 2 to the millimeter.

Pedicle valve unevenly convex in lateral profile with the most convex part at the umbo; anterior profile fairly strongly convex, the convexity greatest in the median region with the sides sloping steeply to the margins. Umbo somewhat narrowly swollen; anterior portion somewhat flattened; lateral slopes to the cardinal extremities steep. Interarea slightly curved, strongly apsacline. Teeth small, delthyrial cavity deep; muscle field long, extending to the middle; anterior ends of diductor scars extended anterior to adductor track.

Brachial valve gently convex in lateral profile, broadly and gently convex in anterior profile, umbo sulcate; sulcus broad and shallow, scarcely defined at the anterior margin; flanks bounding sulcus gently swollen and with gentle slopes to the posterolateral areas. Brachio-phores widely divergent, stout; notothyrial platform somewhat thickened; cardinal process a thin ridge.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|----------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 10.0 | 12.5+ | 12.0 | 4.0 |
| Paratype (" " 116936f) | 10.3 | 12.1 | ? | ? |
| " (brachial valve 116936e) | 10.2 | 13.8 | 12.4 | 3.0 |
| " (" " 116936d) | 8.4 | 12.3 | 11.9 | 1.6 |

Types.—Holotype; 116936a; figured paratypes: 116936d,e; unfigured paratypes: 116936b,c,f.

Horizon and locality.—Wardell formation in Tennessee: In Raccoon Valley, $\frac{3}{4}$ mile northeast of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle.

Pierce formation in the Central Basin of Tennessee: At Pierce Mill, $7\frac{1}{2}$ miles north of Murfreesboro, Rutherford County.

? Lebanon formation in the Central Basin of Tennessee: On Tennessee Highway 16, 5.1 miles north-northwest of Shelbyville, Bedford County.

Discussion.—This is a somewhat variable species characterized by a fairly deep pedicle valve but a very shallow brachial valve. It is suggestive of *G. assimilis*, but that is a more robust form having more nearly equally deep valves. *Glyptorthis virginica* is similar but differs in more robust form, a more prominent brachial sulcus, and deeper brachial valve.

GLYPTORTHIS MULTICOSTELLATA Cooper, new species

Plate 46, F, figures 35-40

Shell large for the genus, wider than long; valves subequally convex; hinge narrower than the greatest shell width at the middle; sides gently rounded; anterior margin broadly rounded; anterior commissure rectimarginate; surface multicostellate; costellae uneven in size, the primary ones the larger and surrounded by finer costellae of several generations; about 10 costellae in 1 mm. at the front margin. Imbrications about 3 to the millimeter.

Pedicle valve gently convex in lateral profile with the maximum convexity in the median half; anterior profile broadly convex; umbonal region slightly swollen; median region gently convex; lateral and posterolateral slopes gentle. Interarea flat, almost catacline; delthyrial cavity wide and deep; anterior ends of diductor scars extended anterior to delthyrial cavity; dental plates well developed; adductor track short, somewhat elevated.

Brachial valve moderately convex in lateral profile with the greatest convexity in the median region; anterior profile broadly but moderately convex; umbonal and median regions swollen; umbo sulcate; sulcus narrow and moderately deep but shallowing and disappearing near the front margin; flanks bounding sulcus moderately swollen; posterolateral areas somewhat flattened; posterolateral slopes moderately steep, short. Notothyrial platform thickened; brachiophores stout and short; cardinal process prominent, stout.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 11.9 | 16.9 | 14.5 | 3.9 |
| Paratype (brachial valve 116938c) | 12.7 | 16.4 | 14.1 | 3.0 |

Types.—Holotype: 116938b; figured paratypes: 116938a,c,e; unfigured paratype: 116938d.

Horizon and locality.—Ridley formation in Georgia: On U. S. Highway 27 just north of Chickamauga Creek, Kensington (T.V.A. 106-SE) Quadrangle.

Discussion.—This species is characterized by its rectangular outline and fairly strongly convex brachial valve. It is very suggestive of *G. virginica* but differs in having finer ornamentation, a pedicle valve not flattened in the anteromedian portion, a more convex brachial valve, and a less pronounced brachial sulcus.

GLYPTORTHIS OBESA Cooper, new species

Plate 47, B, figures 9-12

Shell of medium size for the genus, strongly biconvex with the length and width subequal. Lateral margins gently rounded to nearly straight; anterior margin strongly rounded. Anterior commissure rectimarginate. Surface multicostellate, about 7 costellae occupying the space of 5 mm. at the front margin.

Pedicle valve subhemipyramidal in outline; lateral profile moderately convex with the greatest convexity located in the posterior half. Anterior profile strongly convex. Valve strongly swollen in the midregion, with steep lateral slopes. Slopes to cardinal extremities gently convex. Interarea long, strongly apsacline.

Brachial valve wider than long, strongly convex in both profiles and with the greatest convexity located at the middle. Midregion swollen. Anterior and lateral slopes steep. Slopes to cardinal extremities gently concave. Median sulcus defined at the posterior only, obsolete at the front margin of an adult. Interarea long, orthocline.

Interior with heavy and swollen structures. Pedicle muscle field narrow, thickened at the front and with an elevated adductor track. Ovarian fields large and occupying most of the lateral areas of the interior. Cardinalia of the brachial valve ponderous.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 14.6 | ? | 14.2 | 12.3 | 5.3 |
| Paratype (brachial valve 110068c). | 11.7 | 15.2 | ? | ? | ? |

Types.—Holotype: 110068d; figured paratypes: 110068a,c; unfigured paratypes: 110068b,e,g.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: A little north of the middle of sec. 32, T. 2 S., R. 2 E., 2 to 3 miles northeast of Springer, Carter County.

Discussion.—This species is closest to *Glyptorthis bellarugosa* of any described in this paper. It differs, however, in the possession of a finer sculpture and more convex valves.

GLYPTORTHIS RARA Cooper, new species

Plate 44, B, figures 6-10

Small, characterized by its great width and few strong imbrications. Ornamentation consisting of 20 costae interrupted by 8 strong imbrications. Secondary costae intercalated at about the middle.

Pedicle valve much deeper than the brachial valve and having a fairly long, nearly procline interarea. Most convex at the umbo with long, gently concave umbonal slopes.

Brachial valve very gently convex in both profiles and marked medially by a shallow, narrow sulcus which originates at the umbo and extends to the front margin. Sulcus occupied by a single costa.

Measurements in mm.—Holotype, length 5.4, brachial length 5.1, midwidth 8.4, hinge width 8.2, thickness 3.6.

Types.—Holotype: 110069a; unfigured paratype: 110069b.

Horizon and locality.—Benbolt formation in Virginia: 1 mile west of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—The strong costae, few imbrications, and great width of this little species distinguish it from *G. glypta* and *G. concinnula* which are both of small size.

GLYPTORTHIS SENECTA Cooper, new species

Plate 45, B, figures 7-14

Small for the genus, strongly biconvex, slightly wider than long; cardinal extremities nearly a right angle or slightly obtuse; hinge slightly narrower than, or nearly equal to, the width of the valves at the middle where the maximum width is located. Lateral margins nearly straight; anterior margin broadly rounded; anterior commissure uniplicate. Surface finely costellate, 4 to 7 costellae occupying a space of 2 mm. at the anterior margin. Concentric lamellae fairly closely crowded but variable.

Pedicle valve moderately convex in lateral profile, but strongly convex in anterior profile. Beak prominent; umbonal region convex; median region nearly to front fairly strongly swollen and with steep sides descending to the front and lateral margins. Interarea long, apsacline. Muscle field with elongate and narrow diductor scars; adjustor impressions small, located at base of dental plates, not distinct. Adductor track wide, often strongly elevated. Dental plates receding.

Brachial valve slightly less convex in lateral profile than the pedicle valve; broadly convex in anterior profile. Umbonal region convex, sulcus originating on umbo, shallow, widening to about the middle where it is lost in the anterior third. Flanks convex with moderately steep slopes. Inside the dorsal valve the median ridge extends to a point slightly anterior to the middle. Cardinalia strong and typical for the genus.

Measurements in mm.—

| | Length | Width | Hinge width | Depth |
|-------------------------------|--------|-------|-------------|-------|
| Holotype (pedicle valve)..... | 9.2 | 10.1 | 9.4 | 4.6 |
| Paratype (" " 110070i) ... | 8.7 | 10.1 | 8.8 | 3.6 |
| " (brachial valve 110070g) .. | 7.5 | 9.5 | 9.4 | 2.8 |
| " (" " 110070e) .. | 7.8 | 8.5 | 8.0 | 2.4 |

Types.—Holotype: 110070h; figured paratypes: 110070c,d,f,g,i; unfigured paratypes: 110070a,b,e.

Horizon and locality.—Poteet formation (Yellow Branch member=9-foot

marble) in Virginia: On the road beside Yellow Branch, 5 miles southeast of Rose Hill, Rose Hill (T.V.A. 161-NW) Quadrangle.

Discussion.—This species is characterized by its rectangular form, the anteriorly nearly obsolete brachial sulcus, and the fine costellae. Some pedicle valves show the development of a distinct sulcus at the front margin, and the corresponding part of the brachial valve is so swollen that the sulcus is obliterated. This species is quite unlike any of those described herein. It differs from *G. concinnula* by its anteriorly obsolete brachial sulcus and much more subdued costellae. It is a much smaller shell than *G. assimilis* with finer costellae and less pronounced sulcus.

GLYPTORTHIS SUBCARINATA Cooper, new species

Plate 46, D, figures 18-23

Shell small, wider than long with the hinge about equal to or slightly less than the width at the middle. Sides rounded; anterior margin truncated. Anterior commissure sulcate. Surface multicostellate, costellae numbering about 30, separated by striae about equal to the costellae in width.

Pedicle valve moderately convex in lateral profile with the deepest part near the middle; anterior profile narrowly convex with moderately steep lateral slopes; umbo narrowly convex, the convexity and a strong median costella extending to the front margin as a subcarinate fold; median and anteromedian region somewhat swollen with long, fairly steep lateral and posterolateral slopes. Interarea nearly catacline.

Brachial valve fairly evenly and gently convex in lateral profile; moderately convex and medianly deeply sulcate in anterior profile; umbo somewhat swollen, deeply sulcate; sulcus deepening and widening anteriorly to the front margin. Flanks bounding sulcus swollen; lateral and posterolateral slopes short and gentle.

Measurements in mm.—Holotype, length 6.6, brachial length 6.3, width 9.1, hinge width 8.2, thickness 3.7.

Type.—Holotype: 117987.

Horizon and locality.—Lower Sevier formation in Tennessee: $\frac{1}{4}$ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This is a small species having the appearance of *G. uncinata* but not so deeply sulcate nor so strongly costellate. It is much more strongly sulcate than *G. uniformis* and is also, at least as now understood, a somewhat smaller shell.

GLYPTORTHIS SUBCIRCULARIS Cooper, new species

Plate 49, G, figures 33-40

Shell large for the genus, slightly wider than long and with the hinge considerably narrower than the greatest width which is at the middle, sides rounded, anterior margin gently rounded to truncated. Anterior commissure gently uniplicate; valves subequally convex; surface multicostellate, costellae broadly angular, 5 in 5 mm. at the front margin.

Pedicle valve moderately strongly convex in lateral profile with the greatest convexity in the posterior half; lateral profile strongly and broadly convex; umbonal and lateral regions swollen; sulcus originating about 12 mm. anterior to the beak, narrow and shallow and forming a short tongue; slopes to cardinal extremities very steep. Median costella extending for 3 mm. anterior to the beak where it trifurcates, the resulting 3 costellae extending to the anterior margin. Interarea curved, gently apsacline.

Brachial valve strongly convex in lateral profile with the greatest convexity at about the middle; anterior profile strongly arched and swollen; median region strongly swollen with steep slopes to all margins; umbo sulcate, sulcus narrow and deep, extending to about the middle where its surface is elevated into a low fold; sulcus occupied by 2 costellae at posterior; 2 costellae intercalated inside the posterior 2 at 3 mm.; 2 additional costellae intercalated at about 6 mm. to form a median fascicle of 6 costellae which form the fold. Interarea long and strong, curved to overhang the delthyrium.

Pedicle interior characterized by a deep and broad delthyrial cavity; muscle field wide with diductor ends extended anterior to the delthyrial cavity; adductor track short, elevated; median ridge thick. Teeth stout, fossettes deep. Dental plates long and thick, umbonal cavities nearly filled.

Brachial valve with short, stout brachiophores supported by thick swelling of the notothyrial platform; cardinal process bulbous in the adult.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.9 | 16.7 | 20.4 | 12.2 | 11.9 |
| Paratype (pedicle valve 116940b) .. | 16.2 | ? | 17.6 | 12.6 | 5.5 |
| " (brachial valve 116940a) .. | ? | 17.9 | 20.0 | 13.2 | 7.0 |

Types.—Holotype: 84015; figured paratypes: 116940a,b.

Horizon and locality.—Decorah formation (Ion member) in Iowa: At Decorah.

Same horizon in Minnesota: In a road cut 1.1 miles east of U. S. Highway 52, on the south edge of Cannon Falls; and at Kenyon, Goodhue County.

Discussion.—The rounded outlines and strongly convex valves set this species apart from any of the Appalachian species except *G. equiconvexa*. The latter is very easily separated from *G. subcircularis* by its subquadrate form and heavy shells. *Glyptorthis subcircularis* is similar to *G. bellarugosa* and is probably related to it. The stronger costellae, the subcircular form, the outline, and strong convexity serve to distinguish the two species.

GLYPTORTHIS SULCATA Cooper, new species

Plate 46, E, figures 24-34

Hebertella bellarugosa RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 245, pl. 36, figs. 8, 9, 1911.

Shell small for the genus, with the length and width about equal. Hinge equal in width to the width of the shell or a little less than the greatest width. Cardinal extremities slightly obtuse. Lateral margins straight to well rounded; front

margin broadly rounded. Anterior commissure gently sulcate. Surface multicostellate; costellae subangular and appearing in 3 generations by implantation. A specimen about 12 mm. in length has about 40 costellae which are crossed by closely spaced imbricated lamellae.

Pedicle valve strongly convex in lateral profile with the greatest convexity between the umbo and the middle of the valve. Anterior profile strongly convex. All slopes from swollen preumbonal region steep. Interarea curved, elongate, apsacline. Beak pointed forming an angle of 110° . Delthyrium narrow.

Brachial valve unequally convex in lateral profile, the umbonal region having the greater convexity. Moderately convex anterior to the umbonal region. Anterior profile less convex than that of the pedicle valve and medially sulcate. Sulcus deep at the umbo, widening anteriorly and in old shells becoming much shallower and nearly obsolete at the front margin. Sulcus occupying 5 mm. of the front margin of a specimen 12.5 mm. wide. Two costellae occupying the sulcus at the beak, increasing to 8 at the front margin of an adult. Flanks bounding sulcus moderately convex; slopes to the cardinal extremities steep and concave. Beak much incurved; interarea short.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.5 | 9.0 | 10.8 | 9.3 | 6.8 |
| Paratype (110076a) .. | 12.2 | 10.8 | 12.7 | 9.5 | 9.0 |
| " (110076b) .. | 12.0 | 10.6 | 12.8 | 10.0 | 7.9 |

Types.—Holotype: 110075a; figured paratypes: 110074, 110075b; unfigured paratypes: 110075c; 110076a-e.

Horizon and locality.—Crown Point formation (bed B, division 3 of Brainerd and Seely) in New York: At Chazy and vicinity, Rouses Point (15') Quadrangle; Valcour Island and quarry $\frac{1}{2}$ mile north of the Normal School, Plattsburg, Plattsburg (15') Quadrangle.

Discussion.—This species is characterized by its strongly convex valves, swollen umbonal regions and prominent sulcus on the brachial valve. The species has some features that remind one strongly of *G. concinnula* but has a much larger shell and much more convex valves. Resemblance to *G. bellarugosa*, with which it has long been confused, is remote. Although the size of *G. sulcata* and of the type specimens of *G. bellarugosa* are about the same, the Chazyan shell is more convex in both valves and has deeper sulcus on the brachial valve and a more incurved beak on the pedicle valve.

GLYPTORTHIS TRANSVERSA Cooper, new species

Plate 50, F, figures 24-28

Shell small for the genus, width about $1\frac{1}{4}$ times the length; outline subelliptical; hinge narrower than the width at the middle; sides somewhat narrowly rounded; anterior margin gently rounded; valve subequally convex; anterior commissure rectimarginate. Surface marked by about 26 narrowly rounded

costellae with interspaces about equal to the width of the costellae; imbrications 3 or 4 to the millimeter.

Pedicle valve with lateral profile gently convex; anterior profile very broadly and moderately convex; umbonal and median regions moderately convex; posterolateral slopes moderately steep; interarea curved, strongly apsacline.

Brachial valve moderately convex in lateral profile and very broadly convex in anterior profile; umbo sulcate, sulcus shallow; scarcely attaining the anterior margin; flanks bounding sulcus moderately swollen, the swelling extending to the posterolateral areas which are not depressed.

Measurements in mm.—Holotype, length 5.8, brachial length 5.2, width 7.8, hinge width 6.6, thickness 3.3.

Type.—Holotype: 116939.

Horizon and locality.—St. Martin formation in Quebec, Canada: At Belanger, 2 miles south of Cap St. Martin.

Discussion.—This little species is not like any of the other Chazy species of *Glyptorthis*, most of which have the unequal costellae, subquadrate outline, and wide sulcus of *G. concinnula* and *G. sulcata*. Its transverse form and subequal costellae suggest some of the stratigraphically higher species, but it is not subcarinate like the small Benbolt or Hogskin forms.

GLYPTORTHIS UNCINATA Cooper, new species

Plate 43, B, figures 4-7; plate 46, B, figures 5-10; plate 50, E, figures 19-23

Shell small for the genus, wider than long with the length about two-thirds the width; hinge forming the widest part or narrower than the width at the middle in adults; sides nearly straight, slightly oblique or gently rounded; anterior margin gently rounded; anterior commissure gently and broadly sulcate; surface ornamented by 22 to 24 subangular costae crossed by strong imbrications about 2 to the millimeter; imbrications often produced over the costella into a hollow spine.

Pedicle valve gently convex in lateral profile; somewhat broadly convex in anterior profile with the median region narrowly rounded and the sides sloping steeply; median region narrowly swollen from umbo to anterior margin to produce a poorly defined fold. Interarea long; nearly catacline.

Brachial valve very gently convex in lateral and anterior profiles; umbo sulcate; sulcus deepening and widening anteriorly to occupy about half the width at the front margin; sulcus occupied by 4 to 6 costellae.

Pedicle interior with small teeth; poorly developed lateral plates; short, widely divergent, receding dental plates; deep delthyrial cavity but lightly impressed short muscle field. Brachial interior with thickened cardinal process, short brachiophores, low median ridge, and not greatly thickened notothyrial platform.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 6.1 | 6.0 | 8.7 | 8.6 | 3.9 |
| Paratype (116942) | 5.5 | 5.0 | 7.5 | 7.8 | 3.2 |

Types.—Holotype: 116943a; figured paratypes: 116941a,b, 116942; unfigured paratypes: 116943b,c.

Horizon and locality.—Bromide formation (Mountain Lake member—middle of bed 6) in Oklahoma: At Rock Crossing of Hickory Creek, center sec. 35, T. 5 S., R. 1 E., Carter County; McLish Ranch, sec. 24, T. 1 S., R. 7 E., Johnston County; Nebo, Murray County.

Discussion.—This is a small, somewhat transverse form with fairly strong costellae. It is not to be confused with either of the other two Oklahoma species which are much larger and squarer forms. The small Benbolt and Hogskin species are more finely costellate than *G. uncinata*.

GLYPTORTHIS UNIFORMIS Cooper, new species

Plate 43, E, figures 18-21; plate 46, C, figures 11-17; plate 49, I, figures 45-51

Shell of about medium size for the genus, wider than long; hinge narrower than the shell width at the middle; sides and anterior margin gently rounded; anterior commissure rectimarginate; surface multicostellate, costellae numbering 42 to 44; imbrications 3 to the millimeter.

Pedicle valve unevenly convex in lateral profile with the maximum convexity in the posterior half; anterior half somewhat flattened; anterior profile narrowly rounded in the median part with flat and steep slopes to the margins; umbonal region gently swollen; median and anterior regions somewhat flattened; posterolateral slopes fairly long and gentle. Interarea short, nearly catacline.

Brachial valve moderately convex in lateral profile with the most convexity in umbonal region; anterior profile broadly convex but with a median depression; umbonal region somewhat swollen; sulcus originating at the umbo, expanding anteriorly where it occupies somewhat less than half the width; sulcus defined by marginal costellae larger than the surrounding ones; sulcus occupied by 8 costellae, 2 secondary, 4 tertiary, the remainder implanted on the margin, flanks bounding sulcus gently swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.6 | 10.5 | 13.0 | 12.2 | 6.1 |
| Paratype (116944a) .. | 9.9 | 9.6 | 12.0+ | 11.4 | 5.5 |

Types.—Holotype: 116945a; figured paratypes: 116944a, 116945b, 116946a,b; unfigured paratypes: 116944b,c.

Horizon and locality.—Benbolt formation in Virginia: West slope of hill $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle; Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; north side of U. S. Highway 19, $1\frac{3}{4}$ miles southeast of Hansonville Post Office, Brumley (T.V.A. 205-SE) Quadrangle.

Benbolt formation in Tennessee: At the road corner southwest of Fleanor Mill; roadside 1.6 miles northeast of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle.

Sevier formation in Tennessee: $\frac{1}{4}$ mile northwest of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—Of described species this one is most suggestive of *G. multicostellata*, but it differs in having a less convex brachial valve and a more prominent sulcus on the brachial valve. It is also reminiscent of *G. virginica*, but that species is more coarsely costellated.

GLYPTORTHIS UNIPLICATA Cooper, new species

Plate 47, C, figures 13-17

Shell of about medium size for the genus, slightly wider than long; hinge narrower than width at middle; sides nearly straight or gently rounded; anterior margin gently rounded; anterior commissure gently uniplicate; surface finely multicostellate; costellae numbering about 55, subangular.

Pedicle valve unevenly convex in lateral profile with the posterior third convex and the anterior two-thirds somewhat flattened; anterior profile broadly and gently convex; umbonal and median regions swollen; anterior half occupied by a moderately deep and narrow sulcus that forms a short tongue; areas flanking sulcus gently swollen; lateral slopes short and moderately steep. Interarea gently curved, gently apsacline.

Brachial valve gently convex in lateral profile but with the umbo fairly strongly curved; anterior profile broadly and gently convex; umbonal and median region swollen; umbo sulcate, sulcus narrow and shallow, extending to a point slightly anterior to the middle where it merges in the general valve convexity to form an indistinct fold; sulcus occupied by about 8 costellae. Flanks bounding sulcus slightly swollen; posterolateral slopes gentle.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 13.4 | 14.3 | 12.3 | 5.4 |
| Paratype (" " 116947a) | 10.9 | 12.8 | 11.6 | 3.8 |

Types.—Holotype: 116947b; figured paratypes: 116947a,c; unfigured paratypes: 116947d,e.

Horizon and locality.—Benholt formation (basal part of *Echinosphaerites* bed directly overlying the marble) in Virginia: $\frac{1}{4}$ mile northeast of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is characterized by its rounded outlines and fine costellae. It is suggestive of *G. bellarugosa* but differs from that species in having a fairly prominent pedicle sulcus which is an unusual feature in this genus. The only other species with a marked pedicle sulcus is *G. equiconvexa*, but that is a thick-shelled and robust form having a subquadrate outline.

GLYPTORTHIS VIRGINICA Cooper, new species

Plate 48, D, figures 19-33

Glyptorthis bellarugosa WILLARD (not Conrad), Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 264, 1928.

G. aff. G. bellarugosa BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 93, pl. 90, figs. 25-32, 1942.

Shells of medium to large size for the genus, rectangular in outline; slightly wider than long. Hinge narrower than the width at the middle. Cardinal extremities obtuse or forming a right angle. Lateral margins straight or sloping outward to about the middle. Anterolateral extremities narrowly rounded; front margin straight or slightly emarginate. Greatest width slightly anterior to middle. Anterior commissure rectimarginate to slightly sulcate. Valves subequal in depth; strongly convex. Surface multicostellate, costellae added by implantation and bifurcation in 3 generations. Seven costellae occupy the space of 5 mm. at the front of a valve 17 mm. in length, and 58 costellae were counted on the same valve. Costellae crossed by imbrications swollen into blunt spines. Imbrications marked by fine, concentric, elevated threads.

Pedicle valve unequally convex in lateral view with the greatest convexity located just posterior to the middle. Anterior profile broadly arched. Umbo flattened; slopes to the posterolateral margins moderately steep and slightly concave. Median region swollen; anterior and anterolateral slopes convex, not very steep. Beak only slightly elevated above the posterior margin. Palintrope strongly apsacline to procline; interarea slightly curved.

Brachial valve unequally convex in lateral profile; greatest convexity located slightly anterior to the umbo, anterior two-thirds flattened. Anterior profile moderately convex, broadly indented medially. Sulcus deepest and narrowest at the umbo, widening anteriorly to occupy about one-third the width at the anterior margin. Two primary costellae occupying the sulcus at the umbo, increasing to 7 or 8 costellae at the front margin. Costellae bounding sulcus often stronger and more prominent than the rest. Flanks bounding sulcus moderately swollen; slopes to the lateral and posterolateral margins steep, concave. Beak strongly incurved, often overhanging pedicle interarea; umbo swollen; umbonal region forming deepest part of valve.

Pedicle interior with elongate diductor impressions extending a short distance anterior to the adductor track to the posterior one-third to one-half of the valve. Adductor track wide; adjustor scars small. Median ridge of brachial valve moderately elevated; brachiophores and cardinal process small.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 15.5 | 15.3 | 18.7 | 17.0 | 10.8 |
| Paratype (110082c) | 11.3 | 11.3 | 14.3 | 12.8 | 6.5 |
| " (98209b) | 13.2 | 12.6 | 16.4 | 14.3 | 7.5 |
| " (110082e) | 10.3 | 10.1 | 13.4 | 11.3 | 5.3 |
| " (110086a) | 7.8 | 7.6 | 9.8 | 8.8 | 4.8 |
| " (110086b) | 5.4 | 5.6 | 7.6 | 7.0 | 3.3 |
| " (110086c) | 3.6 | 3.5 | 5.1 | 4.4 | 2.0 |
| " (110086d) | 1.7 | 1.9 | 2.4 | 2.1 | 1.0 |

Types.—Holotype: 98209a; figured paratypes: 98209d, 110082a-e; unfigured paratypes: 98209b,c,e, 110082f-h, 110086a-d.

Growth.—A series of 25 specimens ranging in size from 1.75 mm. in length by 2.5 mm. in width to 15 mm. long by 19 mm. wide shows a progressive lengthening of the shell. The largest specimen in the collection shows that this lengthening has been carried so far that old adults have the length and width almost equal. The youngest specimen shows 12 primary costellae and the intercalation of the second generation.

Horizon and locality.—Wardell formation in Virginia: At Rye Cove and its immediate vicinity, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—Except for *G. assimilis* this species attains the largest size of any *Glyptorthis* encountered in the rocks studied. *G. virginica* can be recognized by the fact that the pedicle and brachial beaks have about the same distance from the margins which gives the valves approximately the same length/width ratio. In some specimens the brachial length actually exceeds that of the pedicle valve, but usually the pedicle valve is slightly longer than the other. Features that will help in recognition of *G. virginica* are the rectangular form, the convex umbonal regions, and the broad, shallow sulcus. *G. virginica* is very close to *G. assimilis* but differs in having a more transverse outline and more subdued ornamentation. Only in extreme cases do the proportions of *G. virginica* approach those of *G. assimilis*.

GLYPTORTHIS sp. 1

Plate 46, A, figures 1-4

This is probably a new species represented by a fine pedicle valve and a crushed, immature complete specimen. Pedicle valve somewhat rectangular in outline; cardinal extremities forming a right angle; sides nearly straight and perpendicular to the hinge; posterolateral extremities narrowly rounded; anterior margin gently rounded; interarea nearly catacline, not curved; teeth small; lateral plates well developed; dental plates short and receding; muscle area with prominent wide diductor scar and a narrow, linear adductor track elevated anteriorly and with a short median ridge anterior to it. Lateral and anterior profiles gently convex.

Surface marked by about 37 narrowly rounded to subangular costellae separated by striae equal to or slightly less than the width of adjacent costellae; imbrications broad, about 3 to the millimeter.

Measurements in mm.—116948, length 9.2, width 10.8, hinge width 9.8, thickness 3.6.

Figured specimen.—116948.

Horizon and locality.—Dark shale just below Eureka quartzite in Nevada: North-facing nose of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—The subquadrate outline and inflated pedicle valve are not like any other described in this report. In absence of the brachial valve it is inadvisable to use a new specific name.

GLYPTORTHIS sp. 2

Plate 49, E, figures 22-26

Shell small for the genus, wider than long; unequally biconvex; hinge slightly narrower than the width at the middle; sides gently rounded; anterior commissure rectimarginate; anterolateral extremities narrowly rounded; front margin very gently curved; surface multicostellate; costellae numbering about 27, and intercalated in 3 generations after the primaries.

Pedicle valve unevenly convex in lateral profile, the posterior half gently convex, the front half somewhat flattened; anterior profile somewhat narrowly convex in the median region but with steep lateral slopes; umbo and posterior half swollen, the slopes in all directions steep to the margins. Median half flattened. Interarea long, strongly apsacline.

Brachial valve gently convex in lateral profile; anterior profile broadly convex and with median region sulcate; umbo sulcate; sulcus forming a triangular depressed area; sulcus occupying about half the width at the anterior margin; sulcus bounded by 2 strong costellae on each side and occupied by 6 costellae, 2 secondary, 2 tertiary and 2 quaternary in appearance.

Measurements in mm.—116949a, length 4.9, brachial length 4.6, width 6.4, hinge width 5.6, thickness 2.6.

Figured specimen.—116949a.

Horizon and locality.—Hogskin member of the Lincolnshire formation in Tennessee: On Maynardville Pike, 1.7 miles north-northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; $\frac{3}{8}$ mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; 1 mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle.

Discussion.—This little species is characterized by a subcarinate pedicle valve and a fairly strongly sulcate brachial valve. It has some resemblance to *G. uniformis* but is smaller and more sulcate. It resembles *G. subcarinata* in size but is differently shaped and not strongly sulcate.

GLYPTORTHIS sp. 3

Plate 43, A, figures 1-3; plate 50, D, figures 14-18

Shell small for the genus, wider than long with the hinge narrower than the greatest width at the middle; sides and anterior margin gently rounded; anterior commissure rectimarginate; surface finely multicostellate; costellae numbering about 66 to 70.

Pedicle valve with moderately convex lateral profile and broadly but fairly strongly convex anterior profile; umbonal and median regions swollen; anterior region somewhat flattened; posterolateral slopes short and moderately steep; surface marked by a median costella stronger than its fellows; costellae appear in about 4 generations. Interarea short, curved, apsacline.

Brachial valve evenly and moderately convex in lateral profile; anterior profile gently convex; umbonal region somewhat swollen; umbo sulcate, sulcus

shallow and wide to a point just anterior to the middle where the sulcus dies out and the valve is evenly convex; sulcus occupied by 10 to 12 costellae.

Shell too imperfect for measurement.

Figured specimens.—116950, 116951.

Horizon and locality.—Little Oak formation in Alabama: On U. S. Highway 31, $\frac{1}{2}$ mile north of the bridge at Pelham, Bessemer Iron District (15') Quadrangle; Bailey Gap road junction with main Cahaba Valley road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Discussion.—Two specimens answering to the above description occur in the collection. These shells are obviously related to *G. concinnula* but appear to be more finely costellated. They may be variations of the common Little Oak species.

GLYPTORTHIS sp. 4

Plate 46, G, figures 41, 42

Shell small for the genus, wider than long; hinge about equal to the midwidth; sides rounded; anterior commissure rectimarginate to faintly sulcate; valves marked by 16 to 18 costellae.

Pedicle valve gently convex in lateral profile, gently convex in anterior profile but with the median region somewhat narrowly swollen; median costella prominent and forming a low fold; flanks gently swollen.

Brachial valve gently convex in both profiles; sulcus originating at umbo widening to the anterior margin, occupied by 3 or 4 costellae; flanks gently swollen; interior with thin cardinal process, somewhat thickened notothyrial platform, and stout brachiophores.

Measurements in mm.—116952a, length 2.8, brachial length 2.7, width 3.6, hinge width 3.5, thickness 1.3.

Figured specimen.—116952a.

Horizon and locality.—McLish formation (zone 45) in Oklahoma: On West Spring Creek, sec. 6, T. 2 S., R. 1 W., Murray County.

Discussion.—The specimens of this species in the National Collection are all small and somewhat variable. They have some characters of young specimens of *Glyptorthis*. A larger collection is needed to make certain whether or not the adult character is one of small size. The species at present cannot be related to any known one from Oklahoma.

Genus ERIDORTHIS Foerste, 1909

Eridorthis FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 14, p. 223, 1909.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 91, 1932.

This unusual genus which is undoubtedly an offshoot from the main stem of *Glyptorthis*, is characterized by a strong development of the fold and sulcus. *Glyptorthis* as a rule is generally only slightly folded, but in *Eridorthis* the sulcus is deep and the fold quite elevated. These features give the genus the appearance of *Oxoplecia* or *Cliftonia*. In making *Eridorthis*, Foerste emphasized

the inversion of the fold and sulcus. In young *Eridorthis* the pedicle valve possesses a short fold and the brachial valve is sulcate, but in the adult a fold arises from the brachial sulcus and the pedicle valve becomes deeply sulcate. This is a common feature in many of the orthoid brachiopods. The presence of the strong fold and sulcus is a more important generic feature than the inversion.

Hitherto *Eridorthis* has not been identified from rocks outside of Kentucky and the Ohio Valley. Its range was Trenton to Eden. The presence of a well-developed species of this genus in the Effna limestone is quite unexpected.

ERIDORTHIS INEXPECTA Cooper, new species

Plate 48, A, figures 1-6

Shell large for the genus, superficially resembling *Oxoplecia*. Subrectangular in outline, wider than long, with narrowly rounded cardinal extremities. Lateral margins broadly rounded, anterior margin broadly rounded. Surface costellate, with 7 to 9 narrowly rounded costellae separated by spaces in width about equal to the width of the costellae; strong concentric lamellae undulate over the costellae and are spaced about 4 to the millimeter.

Pedicle valve unevenly convex in lateral profile with the most convexity in the posterior half, the anterior half being somewhat flattened. Beak broadly obtuse, extending slightly posterior to the posterior margin. Sulcus originating about 3 mm. anterior to the beak, widening gradually to occupy somewhat more than a third of the width at the front. Sulcus deepening anteriorly to form a short rounded tongue. Sulcus bounded by narrowly elevated folds raised above the flanks which are flattened to slightly concave and slope moderately steeply to the margins. Interarea fairly long, strongly apsacline, slightly curved, and with a narrow, open delthyrium. Musculature like *Glyptorthis*.

Brachial valve moderately convex in lateral profile with the anterior third slightly more convex and the maximum convexity at about the middle. Anterior profile broadly convex. Umbo sulcate, sulcus shallow and short, becoming a fold between 3 and 4 mm. from the beak. Fold low and rounded but well differentiated from the flanks which are gently convex and fairly steep sided.

Measurements in mm.—

| | Length | Width | Thickness |
|---------------------------------|--------|-------|-----------|
| Holotype (pedicle valve)..... | 15.7 | 19.7 | 3.2 ? |
| Paratype (" " 110106c)..... | 15.3 | 17.8 | 4.1 |
| " (brachial valve 110106e)..... | 13.2 | 16.4 | 2.0 |
| " (" " 110106b)..... | 15.1 | 19.1 | 5.7 |
| " (" " 110106f)..... | 17.2 | 21.5 | 4.1 |
| " (" " 110106d)..... | 10.9 | 14.3 | 2.3 |

Types.—Holotype: 110104a; figured paratypes: 110106b-e; unfigured paratypes: 110104b,c, 110106a,f,g.

Horizon and locality.—Effna formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; Edinburg formation (Liberty Hall facies), 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle.

Discussion.—This species is larger than the other two known species, *E. nicklesi* Foerste and *E. rogersensis* Foerste, and the fold and sulcus originate nearer the beak than in either of the other two.

Genus PTYCHOPLEURELLA Schuchert and Cooper, 1931

Ptychopleurella SCHUCHERT and COOPER, Amer. Journ. Sci., ser. 5, vol. 22, p. 244, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 92, 1932.

This genus is composed of a considerable number of species, all of small size. The pedicle valve is characterized by a hemipyramidal profile and a long palintrope bisected by a narrow delthyrium. The delthyrium is often restricted by lateral plates along its sides. In addition to the lateral plates the apex of the delthyrium may be occupied by a small plate slightly depressed below the delthyrial edge and usually more or less concave. This plate may be the seat of pedicle attachment and occupies the position of the pedicle scar and the pseudodeltidium of other genera. Internally the muscle field is like that of *Glyptorthis*, but the dental plates, which are of the receding type, are much reduced.

The brachial valve is generally more or less strongly convex and has all the internal details of *Glyptorthis*. Generally the median ridge is more elevated and slender than usual in *Glyptorthis*, and the cardinalia are ponderous for such a small shell.

The most distinctive features of this genus are on the exterior. The pedicle valve is always provided with a prominent median costa which may be elevated or depressed and which usually is accompanied by 2 or 4 additional costae that form a more or less distinct fold. Not infrequently the median costa may be depressed below the level of the fold. The brachial valve is characterized by a corresponding deep sulcus.

Ptychopleurella is not common in the rocks studied. The most prolific locality for the genus and one yielding exquisite specimens, with proper handling, is the Porterfield Quarry, 5 miles east of Saltville, Va. Here it occurs in the thin limestone layers of the transition beds from the Effna formation to the Rich Valley formation. Fossils in the broken pieces of limestone lying on the dumps about the quarry are silicified, and the specimens can be etched free of the matrix. Species not described because of insufficient material occur in the Benbolt formation at Rye Cove, Va., and at two levels in the Edinburg limestone, $\frac{1}{2}$ mile east of Strasburg Junction, Va.

PTYCHOPLEURELLA GLOBULARIS Cooper, new species

Plate 43, D, figures 9-17; plate 82, H, figures 33-39

Shell small for the genus, subrectangular in outline but with rounded angles; unequally biconvex, the pedicle valve having about two-thirds the depth of the brachial valve; hinge slightly narrower than the greatest shell width; sides slightly rounded or nearly straight; anterolateral extremities rounded; anterior margin truncated; anterior commissure rectimarginate to slightly sulcate; surface multicostellate, costellae subangular, distant, separated by spaces about twice

the width of a costella; about 15 to 16 costellae on a valve. Lamellae strong, distant, 3 or 4 in the space of 1 mm.

Pedicle valve fairly strongly convex in both profiles and with the greatest convexity at about the middle; median costella more prominent and more elevated than those surrounding it; anterior end of median costella with a short costella implanted on each side to constitute an indistinct fold; median region swollen and with steep slopes to the margins, giving the valve as a whole a strongly inflated appearance. Interarea gently curved; apsacline. Pedicle interior with large teeth; umbonal cavities filled; muscle field deeply impressed, adductor track long, thickened, and elevated.

Brachial valve strongly convex in lateral profile with the greatest convexity in the umbonal region; broadly convex in anterior profile with the median region broadly indented by a low sulcus; umbo swollen; sulcus originating at umbo and widening to anterior margin where it makes slightly less than half the width; sulcus occupied by 2 strong costellae; flanks bounding sulcus swollen; postero-lateral slopes steep. Brachial interior with stout curved brachiophores; short, thick median ridge and stout cardinal process.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-------|-------------|-----------|
| Holotype | 5.0 | 5.8 | 5.8 | 3.7 |
| Paratype (pedicle valve 116955b)... | 6.8 | 7.4 | 6.0 | 2.9 |
| " (brachial valve 116955a) .. | 5.9 | 7.3 | 6.3 | 2.0 |

Type.—Holotype: 116955c; figured paratypes: 116954a-e, 116955a,b,d; unfigured paratypes: 116955e-h.

Horizon and locality.—Arline formation in Tennessee: 100 yards southwest of the Negro cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is characterized by its globular form and the distant costation. The sulcus is wide and occupied by 2 costae. It is not like any of the other species herein assigned to this genus. It somewhat resembles *Glyptorthis concinnula* but is more strongly and distantly costate and the costae are less numerous.

PTYCHOPLEURELLA GLYPTA Cooper, new species

Plate 42, F, figures 28-39

Fairly large for the genus, subrectangular in outline, wider than long; hinge slightly narrower than the shell width at the middle; sides gently rounded; anterolateral extremities narrowly rounded; anterior margin truncated to emarginated; anterior commissure rectimarginate. Surface marked by 17 strong, subangular costae; imbrications strong, 3 to the millimeter.

Pedicle valve semiconical in lateral profile, the surface almost flat; anterior profile broadly and very gently convex; umbonal region slightly swollen; median region of anterior half depressed to form a shallow sulcus; median costa prominent but depressed anteriorly below those surrounding it and shorter than the

others because it is in the reentrant of the emarginate anterior; sides bounding sulcus gently swollen; interarea long, almost catacline.

Brachial valve fairly strongly convex in lateral profile; anterior profile broadly and fairly strongly convex; umbo slightly inflated; median region somewhat swollen; umbo sulcate, sulcus deep and narrow, occupied by 2 costae; flanks bounding sulcus strongly swollen; lateral and posterolateral slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 5.9 | 5.9 | 8.0 | 7.0 | 4.4 |
| Paratype (116956b)..... | 4.5 | 4.7 | 6.2 | 5.4 | 2.7 |
| " (116956c)..... | 3.9 | 3.8 | 5.6 | 4.6 | 2.1 |

Types.—Holotype: 116956a; figured paratypes: 116956b,d; unfigured paratype: 116956c.

Horizon and locality.—Lenoir formation (calcareenites below Mosheim limestone) in Tennessee: On the southwest side of the cemetery behind Friends Church, north corner of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is abundant in a shaly bed in the sub-Mosheim calcarenites at Friendsville. Interiors are rare; only the brachial one has been seen, and this presents no features unusual to the genus. *Ptychopleurella glypta* attains an unusually large size for the genus. In this respect it differs from the other species described herein. It is somewhat suggestive of *P. porcia* (Billings) but is more coarsely ornamented.

PTYCHOPLEURELLA LAMELLOSA (Raymond)

Plate 42, C, figure 12

Orthidium lamellosum RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 371, 1905.

Orthidium ? lamellosum RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 248, pl. 36, figs. 17, 18, text fig. 24, 1911.

Types.—Paratype: Y.P.M. 2706.

Horizon and locality.—Valcour formation in New York: Valcour Island, Plattsburg (15') Quadrangle; Chazy, Rouses Point (15') Quadrangle; and Crown Point, Port Henry (15') Quadrangle.

PTYCHOPLEURELLA MEDIOCOSTATA Cooper, new species

Plate 42, E, figures 22-27

Shell small, width nearly twice the length; cardinal extremities obtuse; lateral margins narrowly rounded; anterior margin deeply emarginate. Surface costate; a strong and wide median costa occupying the center of the pedicle valve and 7 or 8 costae marking the flanks. Interspaces V-shaped in section and about the same width as the costae. Entire surface covered by closely crowded concentric lamellae.

Pedicle valve hemipyramidal in lateral profile with a nearly flat to slightly concave slope and catacline to strongly aspacline interarea. Anterior profile

broadly convex; beak prominent, pointed, median costa slightly depressed with adjacent costae to form a shallow sulcus; flanks slightly convex but the lateral slopes to the cardinal extremities steep. Delthyrium partially covered by a short, depressed, concave apical plate, possibly the seat of pedicle attachment. Muscle area subcordate in outline with prominent narrow, elongate adductor impressions, a conspicuous adductor field bordered by low ridges. Adjustor impressions small and located at the base of the dental plates. Teeth large, dental plates short and receding. Pallial impressions indistinct.

Brachial valve strongly convex in lateral profile with the most convex part in the strongly arched umbonal region. Anterior profile bilobed. Sulcus originating on the convex umbo, deep and narrow and extending to the anterior margin which is produced into a short, sharp tongue. The 2 costae bounding the sulcus are also depressed below the flanks which are narrowly rounded and have steep slopes to the margins. Interarea long, curved, orthocline to anacline. Sockets deep, brachiophores ponderous with strong cuplike thickenings of callus attaching them to the lateral walls. Notothyrial cavity deep and notothyrial platform thick, supporting a septumlike cardinal process much thickened at its anterior end. Median ridge strong and thick.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 3.9 | 6.2 | 5.0 | 2.5 |
| Paratype (brachial valve 110097b) .. | 4.2 | 5.8 | 4.7 | 2.0 |

Types.—Holotype: 110097a; figured paratypes: 110097b-d.

Horizon and locality.—Effna-Rich Valley formations in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—A structure rarely preserved in these shells appears in the specimens on which this species is based. This is the small apical plate at the apex of the delthyrium. This is slightly depressed below the margin of the delthyrium and is attached to the sloping face of the lateral plates bordering the delthyrium. This plate is unlike a true pseudodeltidium in its concave form and may have been the seat of pedicle attachment. The lateral plates, possibly homologous to deltidial plates, are fairly well developed in the specimens studied.

For comparison see *P. rectangularata*.

PTYCHOPLEURELLA OKLAHOMENSIS Cooper, new species

Plate 42, G, figures 40-44

Shell small, wider than long with the hinge slightly narrower than the greatest shell width which is at the middle. Sides narrowly rounded; front margin broadly rounded. Surface costate, about 16 broadly angular costae with interspaces about equal in width to the width of the costae. Entire surface regularly imbricate with about 4 to 5 imbrications to a millimeter.

Pedicle valve hemipyramidal with a very gently convex lateral profile but a broadly convex anterior profile. Beak and umbo smooth. Median 5 costae slightly elevated to form a broad indistinct fold. Slopes to cardinal extremities

and sides long and gentle. Median costa slightly depressed below those surrounding it. Palintrope strongly apsacline to nearly procline; interarea nearly flat.

Brachial valve moderately convex in lateral profile, more so than the pedicle valve; anterior profile broadly convex with a depressed median area corresponding to the sulcus. Umbonal region sulcate; sulcus deep at the umbo, widening and becoming more shallow anteriorly to occupy approximately half the width at the front margin. Sulcus occupied by 2 costae; space between the 2 costae forming the deepest part of the sulcus and corresponding to the median costa of the pedicle valve. Flanks moderately convex, fairly broad. Slopes to cardinal extremities concave, short and steep.

Measurements in mm.—

| | Length | Dorsal length | Width | Hinge width | Thickness |
|--------------------------------------|--------|---------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 2.6 | ? | 4.8 | 4.3 | 1.0 ? |
| Paratype (brachial valve 110095a). ? | | 3.7 | 5.5 | 5.2 ? | 0.8 ? |

Types.—Holotype: 110095b; figured paratype: 110095a; unfigured paratypes: 110095c-e.

Horizon and locality.—McLish formation in Oklahoma: Section along and west of U. S. Highway 77, sec. 25, T. 2 S., R. 1 E., 2 to 3 miles north of Springer, Carter County.

Discussion.—This little species has the form and size of *P. lamellosum* but differs in not possessing the deep sulcus of the pedicle valve which is a conspicuous feature of the New York shell. The Oklahoma species has less costae than the New York shell.

PTYCHOPLEURELLA PORCIA (Billings)

Plate 42, B, figures 10, 11

Orthis porcia BILLINGS, Canadian Nat. Geol., vol. 4, p. 439, figs. 16-18, 1859; Geol. Canada, p. 130, fig. 58, 1863.

Clitambonites porcia (Billings) RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 248, pl. 36, figs. 15, 16, 1911.

This is a small species, finely multicostellate and finely imbricate. The lateral margins are gently rounded and the cardinal angles obtuse. Interarea orthocline; delthyrium very narrow. This species has the external features of *Ptychopleurella* rather than *Clitambonites*. Raymond states that it has a narrower "deltidium" and spondylium than *Clitambonites multicostus*. However, examination of the type specimen indicates that no deltidium is present and that the spondylium is not visible.

Types.—Holotypes: G.S.C. 1044.

Horizon and locality.—St. Martin formation, Island of Montreal, Quebec, Canada.

PTYCHOPLEURELLA RECTANGULATA Cooper, new species

Plate 42, D, figures 13-21

Shell small, subrectangular in outline; hinge slightly narrower than the greatest shell width; cardinal extremities obtuse; sides rounded; anterior margin

slightly emarginate. Surface of the pedicle valve marked medially by a strong, narrow costa extending from the beak to the anterior margin and on each side is intercalated a small costa. Median costa generally elevated above those surrounding it, and the area occupied by the 2 or 3 neighboring costae is flattened. Surface on each side of median costa marked by about 8 costae. Brachial valve marked medianly by a deep sulcus extending from near the beak to the front margin. Sulcus broadly V-shaped in section and occupied by 4 or 5 costae.

Pedicle valve hemiconical, with nearly flat lateral profile and slightly protuberant beak; anterior profile broadly but gently convex. Lateral slopes flattened and moderately steeply inclined. Interarea catacline. Muscle field short, not strongly thickened. Dental plates very short, receding. Apical plate only slightly developed.

Brachial valve moderately convex in lateral profile with the greatest curvature at the umbo; anterior profile bilobed. Flanks bounding sulcus moderately swollen with steep posterolateral slopes but gentle anterior and lateral slopes. Notothyrial platform deep, cardinal process a simple septum; median ridge reaching slightly anterior to the middle, fairly stout.

Measurements in mm.—Holotype, length 3.7, width 5.0, hinge width 3.9, thickness 3.7.

Types.—Holotype: 110101a; figured paratypes: 110101b-e; unfigured paratypes: 110101f-k.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species differs from *P. mediocostata*, with which it occurs, by its less transverse outline, less emarginate anterior margin, more slender and less depressed median costa, and the slight development of the apical plate of the pedicle valve.

PTYCHOPLEURELLA SULCATA Cooper, new species

Plate 50, I, figures 40, 41

Species represented by two fairly well preserved specimens and a fragmentary one. Exterior usual for the genus; pedicle valve youthful, somewhat concave in lateral profile, broadly triangular in anterior profile; median costa prominent, larger than the others and with 2 intercalated ribs on each side forming a median fascicle. Flanks gently swollen and marked by 7 costae.

Brachial valve moderately convex in lateral profile with the maximum convexity at the umbo; anterior profile broadly convex but with the median region deeply sulcate; sulcus originating at the umbo, deep, and deepening to the anterior margin where it occupies slightly less than half the width; sulcus containing 4 costae, 2 intercalated near the beak and the other 2 at about 1 mm. anterior to the beak. Flanks bounding sulcus narrowly but not strongly swollen; posterolateral slopes steep.

Measurements in mm.—

| | Length | Width |
|--|--------|-------|
| Holotype (brachial valve) | 5.2 | 6.9 |
| Paratype (pedicle valve 110108b) | 3.3 | 5.5 |

Types.—Holotype: 110108a; figured paratype: 110108b.

Horizon and locality.—Oranda formation in Virginia: ½ mile west of Strasburg, Strasburg (15') Quadrangle; 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Discussion.—This species is characterized by its large size, deep sulcus, and the manner of implantation of the costae occupying the sulcus. It is of about the size of *P. globularis* but differs in having 4 costae in the sulcus rather than 2. It suggests *P. uniplicata*, but that species has only 2 costae in the sulcus.

PTYCHOPLEURELLA UNIPLICATA Cooper, new species

Plate 49, H, figures 41-44

Shell of about usual size for the genus, subrectangular in outline; sides narrowly rounded; anterior commissure sulcate; anterior margin nearly straight. Pedicle valve unequally convex in lateral profile, the posterior third somewhat concave, the anterior two-thirds flattened to gently convex; median costa raised to form a low fold; flanks flattened and sloping gently to the margins, marked by 6 costae.

Brachial valve moderately convex in lateral profile with the maximum convexity at about the middle; anterior profile broadly convex but with the median region sulcate; sulcus deep and wide, occupied by 2 costae intercalated about 1 mm. anterior to the beak; flanks bounding sulcus fairly strongly convex; posterolateral slopes steep.

Measurements in mm.—

| | Length | Width |
|--|--------|-------|
| Holotype (pedicle valve 110110a)..... | 5.2 | 7.2 |
| Paratype (brachial valve 110110b)..... | 3.7 | 4.7 |

Types.—Holotype: 110110a; figured paratype: 110110b.

Horizon and locality.—Benbolt formation in Virginia: 1½ miles west of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is suggestive of *P. sulcata* from the Oranda formation of Virginia, but the pedicle valve is more convex and the brachial valve has only 2 costae occupying the sulcus. The species is uncommon in the Benbolt formation.

Family ANOMALORTHIDAE Ulrich and Cooper, 1936

Orthacea having a sessile spondylium.

Genus ANOMALORTHIS Ulrich and Cooper, 1936

Anomalorthis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 622, 1936; Geol. Soc. Amer. Special Pap. 13, p. 126, 1938.

This genus is fairly common in the upper part of the Pogonip formation in Nevada and the Swan Peak formation of Utah. In Oklahoma *Anomalorthis* is abundant in the Oil Creek formation which is the correlate of the high Pogonip. It is also known from an undescribed species from the Joins formation of Oklahoma. This species is considerably coarser in its costellation than the Oil Creek species.

ANOMALORTHIS LONENSIS (Walcott)

Orthis lonensis WALCOTT, U. S. Geol. Surv. Mon. 8, p. 74, pl. 11, figs. 6, 6a, 1884.

Anomalorthis lonensis (Walcott) ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 127, pl. 21E, figs. 18, 22-25, 27, 1938.

Types.—Holotype: 17232; hypotypes: 91281a-d; figured specimen: 91280.

Horizon and locality.—Upper Pogonip group in Nevada: At Lone Mountain, 18 miles northwest of Eureka, Roberts Mountains (1°) Quadrangle.

Swan Peak formation in Utah: 1 mile west of Ibex, in Smooth Canyon, Confusion Range, Millard County.

ANOMALORTHIS NEVADENSIS Ulrich and Cooper

Plate 78, B, figures 10-12

Anomalorthis nevadensis ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 127, pl. 21D, figs. 13-17, 1938.

Types.—Holotype: 92853c; paratypes: 92853a,b.

Horizon and locality.—Upper Pogonip group in Nevada: At west base of Lone Mountain, 18 miles northwest of Eureka; Ikes Canyon, east side Toquima Range, Roberts Mountains (1°) Quadrangle. North end Ely Springs Range, Highland (15') Quadrangle. Pogonip Ridge, White Pine District.

ANOMALORTHIS OKLAHOMENSIS Ulrich and Cooper

Plate 78, C, figures 13-20

Anomalorthis oklahomensis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 622, 1936; Geol. Soc. Amer. Special Pap. 13, p. 128, pl. 22A, figs. 1-6, 1938.

Subpyramidal in profile and with the pedicle valve having a greater depth than the brachial one; hinge about as wide as the width at the middle or slightly less; multicostellate, costellae fine, rounded, subequal, 3 to 5 in the space of 1 mm. at the front margin of a valve 11 mm. long.

Pedicle valve hemipyramidal with a strongly procline interarea often slightly convex outward; umbonal region gently convex but front median part depressed to form a conspicuous sulcus; lateral profile nearly flat; anterior profile steeply rounded. Flanks bounding sulcus convex; slopes to the cardinal margin slightly concave.

Brachial valve gently convex in lateral and anterior profiles; umbo and median region marked by a shallow, narrow sulcus; median region swollen; slopes to the cardinal extremities short and moderately steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------------------|--------|-----------------|-------|-------------|-----------|
| Lectotype (pedicle valve) | 7.9 | ? | 13.8 | 13.7 | 5.6 |
| Paratype (pedicle valve 92854e) .. | 12.5 | ? | 16.8 | 19.0 ? | 5.7 ? |
| “ (brachial valve 92854b) . | ? | 10.7 | 13.4 | 11.8 ? | 2.3 ? |
| Hypotype (“ “ 110182) . | ? | 17.6 | 21.0 | ? | ? |

Types.—Lectotype: 92854a; figured paratypes: 92854b, 92855, 110182; unfigured paratypes: 92854c-e.

Horizon and locality.—Oil Creek formation in Carter County, Okla.: Along Henryhouse Creek; on U. S. Highway 77, sec. 25, T. 2 S., R. 1 E., 2 to 3 miles north of Springer; north end of Criner Hills. In Murray County, Okla.: in NE $\frac{1}{4}$ sec. 22, T. 2 S., R. 1 E., 4 to 5 miles due north of Glenn; along the road 2 miles southwest of Nebo; second dam on Spring Creek; 1 mile northwest of Hickory; section on Falls Creek. In Johnston County, Okla.: on west branch of Sycamore Creek, sec. 27, T. 3 S., R. 4 E.; middle of the south side sec. 34, T. 2 N., R. 6 E., 1 mile southwest of Franks.

Discussion.—This species is abundant throughout the Oil Creek formation in Oklahoma. It is a somewhat variable species, and collection of better or more material may see the splitting out of additional species. It is a fact that to date no specimens have been collected with both valves together. It is usually found as scattered valves in bryozoan debris or in coarse calcarenite, both the products of strongly agitated waters.

ANOMALORTHIS UTAHENSIS Ulrich and Cooper

Anomalorthis utahensis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 622, 1936; Geol. Soc. Amer. Special Pap. 13, p. 129, pl. 22 C, figs. 11-13, 16, 17, 19-24, 1938.

Types.—Holotype: 91284; paratypes: 91283a-f; 91286.

Horizon and locality.—Swan Peak formation in Utah: Smooth Canyon, 1 mile west of Ibex, Confusion Range. Kanosh shale in western Utah.

Upper Pogonip group in Nevada: On west side Snake Range, 25 miles south of Osceola.

Family DINORTHIDAE Schuchert and Cooper, 1931

Progressive Orthacea having a subquadrate muscle field in the pedicle valve, *Orthis*-like brachioophores, and a simple cardinal process with crenulated myophore.

Genus DINORTHIS Hall and Clarke, 1892

Dinorthis HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 195, 222, 1892.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 93, 1932.

DINORTHIS ATAVOIDES Willard

Plate 57, A, figures 1-11

Dinorthis atavoides WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 270, pl. 2, fig. 4, 1928.—BUTTS, Virginia Geol. Surv. Bull. 52 pt. 2, p. 43, pl. 73, figs. 55-61, 1942.

Shell fairly large for the genus, length about one-third less than the width; greatest width at about the middle; cardinal extremities obtuse, rounded. Lateral margins moderately rounded, anterior margin gently rounded to truncated. Anterior commissure gently and broadly uniplicate. Valves unequally convex, the brachial valve having the greater depth and convexity. Length of hinge slightly exceeding the valve length. Surface marked by 30 to 36 elevated and narrowly rounded costae separated by spaces equal to or slightly wider than the costae. No bifurcations observed. Median costae largest and widest spaced.

Pedicle valve very gently to moderately convex in lateral profile, gently convex in anterior profile. Umbonal region moderately swollen and continued anteriorly to about the middle of the valve as a low, wide, and poorly defined fold. Posterolateral slopes gently concave. Anterior median half depressed into a shallow, wide sulcus; anterolateral areas very gently convex to flat. Interarea short, curved, apsacline. Beak scarcely protruding beyond the brachial beak.

Brachial valve evenly and moderately convex in lateral profile, the greatest convexity located about at the middle; strongly convex in anterior profile. Posterolateral slopes steep; anterior and anterolateral slopes moderately steep. Median and anteromedian regions swollen. Interarea short, apsacline. Beak curved over pedicle interarea. Sulcus narrow and indistinct on umbo, narrow and shallow anteriorly or absent.

Pedicle muscle field slightly longer than wide; adductor track narrow; diductor impressions wide, not elongated noticeably anterior to the front of the muscle field. Brachial cardinalia characterized by delicacy and compactness for such large shells. Median ridge short, adductor field small.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (110283k)..... | 17.7 | 17.8 | 24.6 | 17.3 | 8.5 |
| " (98216a)..... | 19.5 | 19.6 | 26.5 | ? | 10.2 |
| " (98215)..... | 17.0 | 17.2 | 23.0 | 16.2 | 8.2 |

Types.—Holotype: M.C.Z. 8605; figured paratype: M.C.Z. 8606; figured hypotypes: 98215 (figured by Butts, 1942), 98216a, 110283e,g,k; unfigured hypotypes: 110283a-d,f,h-j, l-n.

Horizon and locality.—Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; Oakman; on shore of a small point in Norris Reservoir, $\frac{1}{2}$ mile south-southeast of Oakman Tunnel, Dutch Valley (T.V.A. 154-SE) Quadrangle; ridge paralleling the railroad, Maloneyville, John Sevier (T.V.A. 146-SE) Quadrangle; 90 to 120 feet above the "Mosheim" limestone on U. S. Highway 25E, 1 mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; $\frac{3}{4}$ mile southwest of Mount Eager Church, 0.2 mile north-northwest of the main road, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle.

Lincolnshire formation in Virginia: North of Copper Creek between Speers Ferry and Clinchport, Clinchport (T.V.A. 188-NW) Quadrangle; Marcem Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle; Templeton Branch, 5 miles northwest of Gate City; Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; 1.8 miles S. 4° W. of Bethel Church, Harrisonburg (15') Quadrangle; 1 $\frac{1}{2}$ miles northwest of Oakwood; on Virginia Highway 100 just north of junction with Highway 42, Staffordsville, Giles County; northwest slope of Sinking Creek, 2 $\frac{1}{2}$ miles southwest of Huffman; about 200 feet east of Whistle Creek bridge on U. S. Highway 60 and 1,200 feet north of the highway, 1 $\frac{1}{2}$ miles northwest of Lexington, Lexington (15') Quadrangle; branch of Moccasin Creek, $\frac{3}{4}$ mile south-southwest of Tumbez, Moll Creek (T.V.A.

196-SE) Quadrangle; Hoge Farm, $1\frac{3}{4}$ miles due east of Central Church, Burkes Garden (15') Quadrangle.

"Lenoir" formation in Alabama: 7 to 11 feet above the "Mosheim" limestone, Clifton Terrace section, Birmingham, Birmingham (30') Quadrangle.

Discussion.—This species can be readily recognized by its direct, unbifurcated costae and its thick, robust appearance. The posterior portion of both valves is quite deep, and the front part of the pedicle valve is not strongly sulcate. The species suggests a large form of *D. holdeni* from which it may be descended. There are, however, important differences between the two. *Dinorthis holdeni* is a smaller species which is in general not quite as wide as *D. atavoides* and is differently proportioned. The front part of the pedicle valve is more depressed and the valve comparatively shallower than that of *D. atavoides*.

Dinorthis willardi also suggests the species in question by its direct and unbifurcated costae, but it is much more slender in lateral profile and the pedicle valve is more concave and more shallow while the brachial valve is not so deep as the same valve in *D. atavoides*.

DINORTHIS HOLDENI (Willard)

Plate 57, C, figures 14-28

Plectorthis holdeni WILLARD, Bull. Mus. Comp. Zool. Harvard Coll., vol. 68, No. 6, p. 262, pl. 1, fig. 5, 1928.

Shell small for the genus, wider than long with the greatest width at about the middle; cardinal extremities obtusely rounded. Lateral margins evenly rounded, front margin truncated. Anterior commissure gently uniplicate to nearly straight. Valves convexi-concave. Hinge width slightly greater than the valve length. Surface marked by 30 to 33 narrowly rounded costae having interspaces equal to or greater than the width of the costae. Costae of median region more widely spaced and somewhat larger and wider than those on the flanks.

Pedicle valve with umbonal region somewhat narrowly swollen and forming the only strongly convex portion of the valve; posterolateral slopes gently concave. Beak prominent. Lateral profile with posterior half convex but anterior half gently to moderately concave. Anterolateral areas flattened. Interarea moderately long, strongly apsacline to almost catacline in position.

Brachial valve with lateral profile unevenly convex and with the maximum convexity located just posterior to the middle. Umbonal region marked by a shallow and narrow sulcus extending, more or less well defined, to the anterior margin. Median and anterolateral areas gently swollen; posterolateral slopes gentle. Interarea short, nearly orthocline. Cardinal extremities deflected toward the brachial valve.

Interior: Muscle area of pedicle valve nearly square, pallial trunks short, appearing as raised ridges having the usual course for the genus. Median ridge of brachial valve extending for about one-third the length; adductor field small.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (110302b)..... | 14.1 | 14.3 | 18.9 | 14.8 | 5.7 |
| " (110302a)..... | 13.8 | 14.7 | 18.2 | 14.4 | 6.6 |
| " (110302c)..... | 8.8 | 8.8 | 11.2 | 9.5 | 3.8 |

Types.—Holotype M.C.Z. 8595; figured hypotypes: 110301b-d, 110302a, 110304d-g, 110309a; unfigured hypotypes: 110301a, 110302b,c, 110304a-c, 110309b-g.

Horizon and locality.—Elway formation (blocky chert of Cooper and Prouty) in Tennessee: Along U. S. Highway 25W, 4.7 miles south of Clinton, Powell Station (T.V.A. 137-SE) Quadrangle; Evans Ferry section, on U. S. Highway 25E about 1 mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; $\frac{1}{2}$ mile northeast of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Elway formation (blocky chert of Cooper and Prouty) in Virginia: Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; on the road to Mountain Lake at the road fork, $\frac{1}{2}$ mile north of the highway, at base of mountain, $1\frac{1}{2}$ miles northwest of Newport, Giles County; road cut on Route 64, $\frac{1}{3}$ mile north of Dickensonville, Hansonville (T.V.A. 205-SW) Quadrangle; 1 mile north of Belfast Mills, Saltville (T.V.A. 212-NE) Quadrangle; on the road along Purgatory Creek, $1\frac{1}{2}$ miles southwest of the Dunkard Church, 6 miles north of Buchanan, Natural Bridge (15') Quadrangle; Sinking Creek in Giles County, 10 miles north of Blacksburg; northwest side of knoll, 1 mile west of old Rosedale, Russell County; east of Moccasin Creek on Virginia County Road 679, $\frac{3}{4}$ mile south of Tumbez, Moll Creek (T.V.A. 196-SE) Quadrangle; 1.2 miles southwest of Collierstown, Rockbridge County; road from Gate City to Hills Station, 1 mile north of Copper Creek, Scott County.

Whistle Creek formation in Virginia: Along Whistle Creek, $1\frac{1}{2}$ miles northwest of Lexington, Lexington (15') Quadrangle; on Virginia County Road 602, $5\frac{1}{2}$ miles S. 82° W. of Middlebrook, Augusta County.

Discussion.—This species suggests a small variety of *D. atavoides* in general configuration of the valves but is smaller and less robust. In lateral profile the brachial valve of *D. holdeni* is not evenly convex, and the pedicle valve is generally more concave anteriorly than is true of specimens of *D. atavoides*. The latter is also a proportionately wider species than *D. holdeni*.

DINORTHIS INTERSTRIATA Willard

Dinorthis pectinella HALL (not Emmons), 2nd Ann. Rep. New York State Geol., pl. 34, figs. 39-40, 1883.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pl. 5, figs. 27, 28, 1893. *D. interstriata* WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 270, 1928.

This species is distinguished by its author from *D. pectinella* (Emmons) by the presence of a fine rib or costella between each pair of larger ones. The type specimen is from the Trenton of New York, but Willard identifies the species in the Virginia "Ottosee." It has not been identified in the National Collections.

Type.—Holotype: A.M.N.H. 692 (larger specimen).

Horizon and locality.—"Ottosee" = Benbolt? in Virginia: Fugates Hill, Bristol (30') Quadrangle. Trenton limestone in New York: On Dry Sugar River, Lewis County.

DINORTHIS SWEENEYI (N. H. Winchell)

Plate 57, B, figures 12, 13; plate 65, C, figures 13-17

Illustrations of this species have been introduced to show the presence of a pseudodeltidium in the genus and also to show the variability of the ribbing. The occurrence of the pseudodeltidium is sporadic but is well known in the Minnesota species. Of Appalachian species only *D. willardi* shows this structure. Many of the species of the Appalachians do show intercalated costae along the margins, particularly in the vicinity of the posterolateral extremities. *Dinorthis sweeneyi* is usually without intercalated ribs, but a few specimens, such as the old adult figured herein (pl. 65), show them.

Figured specimens.—48861, 118020a.

Horizon and locality.—Decorah formation (Ion member) in Minnesota: At St. Paul; and Cannon Falls, Goodhue County.

DINORTHIS TENUIS Cooper, new species

Plate 72, A, figures 1-5

Shell fairly large for the genus, wider than long; hinge narrow; sides rounded; anterior margin broadly rounded; anterior commissure rectimarginate; surface costate, costae numbering about 38, undivided and primary.

Pedicle valve with unevenly convex lateral profile, the umbonal region gently convex but the valve anterior to the umbo moderately concave; maximum concavity in the anterior half; anterior profile broadly and gently concave. Umbonal region gently swollen; beak small; sides somewhat flattened. Interarea short, nearly catacline.

Brachial valve moderately convex in lateral profile, broadly and gently convex in anterior profile; median region somewhat swollen; lateral slopes long and gentle; anterior half marked medianly by a shallow, narrow, and poorly defined sulcus.

Measurements in mm.—Holotype, length 16.2, brachial length 16.4, width 24.6, thickness 4.7.

Type.—Holotype: 116974.

Horizon and locality.—Sevier formation in Tennessee: On the east side of the road, 2.7 miles S. 7° W. of Athens, Athens (T.V.A. 125-NE) Quadrangle; basal 2 feet of argillaceous nodular limestone 100 feet above the Meadow marble in a glade $\frac{3}{4}$ mile N. 10° E. of Meadow Station, Meadow (T.V.A. 139-NW) Quadrangle; Marysville road, 2 miles southeast of Friendsville, Binfield (T.V.A. 139-NE) Quadrangle; cobbly layer in Sevier, $\frac{1}{2}$ mile north of Meadow, Meadow (T.V.A. 139-NW) Quadrangle.

Tellico formation in Tennessee: 1.6 miles south-southwest of Toqua School, Vonore (T.V.A. 139-SW) Quadrangle.

Discussion.—This species is characterized by its slender profile and transverse form. It is very close to *D. willardi* but differs in its more transverse outline, more concave pedicle valve, and much less convex brachial valve.

DINORTHIS TRANSVERSA Willard

Plate 58, B, figures 4-10; plate 58, C, figures 11-27; plate 268, J, figures 45-47

Dinorthis transversa WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 271, pl. 2, figs. 1, 2, 6, 1928.—BUTTS, Virginia Geol. Surv., Bull. 52, pt. 2, p. 83, pl. 85, figs. 14-16, 1942.

Dinorthis quadriplicata WILLARD, idem, p. 271, pl. 1, fig. 13; pl. 3, figs. 5, 6, 1928.

Species variable, outline subrectangular, width greater than length, greatest width at about the middle. Cardinal extremities rounded, varying from nearly a right angle to obtuse. Lateral margins broadly rounded, generally sloping slightly toward the center; front margin nearly straight: anterolateral extremities somewhat narrowly rounded. Anterior commissure broadly uniplicate. Surface multicostate; median 4 to 6 costae generally stronger than the others and usually unbifurcated in young parts of the shell. Costae on the flanks usually bifurcated near their midlength, but on old or large specimens additional bifurcation takes place near the front margin creating 3 generations of costae. Some specimens show bifurcation of the larger median costae at the front.

Pedicle valve in anterior profile gently to moderately concave; in lateral profile umbonal region more or less strongly convex, while the front two-thirds are moderately to strongly concave. Swollen umbonal region short; median strong costae often indistinctly define a poorly developed fold at least in the posterior half. Interarea short, nearly procline. Flanks varying from concave to flat or very gently convex.

Brachial valve moderately convex in lateral profile with the greatest convexity at about the middle; anterior profile moderately to strongly rounded, often with a moderately strong median depression. Sulcus originating at the beak, moderately to strongly impressed and generally extending to the anterior margin where it usually is shallower than on parts posterior to the margin. Flanks bounding sulcus narrowly swollen. Posterolateral slopes generally steep. Interarea short, orthocline.

Pedicle valve with muscle area slightly wider than long, tapering slightly posteriorly. Adductor field large, nearly circular. A slight elevation separates anterior ends of diductor impressions. Median ridge of brachial valve not quite reaching center, cardinalia small.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---|--------|-----------------|-------|-------------|-----------|
| Holotype | 20.7 | 21.2 | 30.6 | 22.0 | ? |
| Hypotype (110332a) | 17.4 | 18.1 | 23.9 | 21.2 | 6.7 |
| Holotype (<i>D. quadriplicata</i>) .. | 19.7 | ? | 24.9 | 18.5 ? | ? |
| Hypotype (98038) | 17.4 | 18.5 | 25.1 | 17.3 | 6.8 |
| " (110320) | 13.0 | 14.1 | 19.7 | 17.2 | 3.9 |
| " (116977) | 20.5 | 21.8 | 30.4 | 22.0 | 8.9 |
| " (111800a) | 20.6 | 21.4 | 30.0 | 24.9 | 7.6 |

Types.—Holotype: M.C.Z. 8603; figured paratype: M.C.Z. 8604; figured hypotypes: 110370, 111799, 111800a,b, 116975, 116976a,b,c, 116977, 118024a,b; unfigured paratypes: 98030, 110332a, 116800c,d. Holotype of *D. quadruplicata*: M.C.Z. 8602; figured hypotypes: 116976a,b, measured hypotypes: 98038, 110320.

Horizon and locality.—Benbolt formation in Tennessee: 30 feet above the "Stones River" 100 yards west of the store at junction of Tennessee Highway 33 and the Flint Creek road, Maynardville (T.V.A. 145-SE) Quadrangle; Winstead Post Office (Shagtown), Anderson County; Raccoon Valley, 18 miles north of Knoxville; Evans Ferry, north of Indian Creek on U. S. Highway 25E, Howard Quarter (T.V.A. 162-NW) Quadrangle; Tennessee Highway 33 at Nicely and Palmer's store, $\frac{1}{2}$ mile east of Kate, Maynardville (30') Quadrangle; head of Flint Creek, $1\frac{1}{2}$ miles northeast of Acuff, Powder Springs (T.V.A. 154-SW) Quadrangle; 1 mile west of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; $1\frac{1}{2}$ miles northeast of Lone Mountain, east of Ball Creek on the road to Tazewell, Tazewell (T.V.A. 154-NE) Quadrangle; 1 mile southeast of White Horn, Bulls Gap (T.V.A. 171-SE) Quadrangle; north side of the highway, 1.6 miles northeast of Lee Valley (T.V.A. 171-NW) Quadrangle; west side of the sharp loop of the road down Flint Creek, NW $\frac{1}{4}$ center subquad., Powder Springs (T.V.A. 154-SW) Quadrangle.

Benbolt formation in Virginia: At Fugates Hill, north of Mendota, Bristol (30') Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles due south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; Brick Church $1\frac{1}{2}$ miles southwest of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; 5 miles north of Wytheville, Wythe County; south side of Mount Hagan School, southeast corner of the NE. subquad., Hilton (T.V.A. 197-NW) Quadrangle; 1 mile east of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; $\frac{1}{8}$ mile south of Gate City, Gate City (T.V.A. 188-NE) Quadrangle; north side of U. S. Highway 19, 1 mile due north of Belfast Mills, Saltville (T.V.A. 212-NE) Quadrangle; Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; just east of Meridian 17°30", east of Moccasin Creek, north edge of Mendota (T.V.A. 197-NW) Quadrangle; $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle; $\frac{1}{4}$ mile southeast of Green Valley Church, Brumley (T.V.A. 205-SE) Quadrangle; $\frac{1}{2}$ mile southeast of Richpatch, Eagle Rock (15') Quadrangle; north side of U. S. Highway 19, $1\frac{3}{4}$ miles southeast of Hansonville, Brumley (T.V.A. 205-SE) Quadrangle; Virginia Highway 74, $5\frac{1}{2}$ miles east of its junction with U. S. Highway 54 (Tennessee 71), Hilton (T.V.A. 197-NW) Quadrangle; vicinity of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; sandstone $\frac{1}{2}$ mile southeast of Mooney Cemetery, 1 mile north-northwest of Otes, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Edinburg formation (*Nidulites* zone) on Strasburg (15') Quadrangle, Virginia: In a field on the east side of U. S. Highway 11, $1\frac{1}{4}$ miles north of Strasburg; Edinburg formation (upper part *Cyrtonotella* beds), along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg; ravine at switch about $\frac{1}{8}$ mile east of Strasburg Junction.

Shippensburg formation (Pinesburg member) in Maryland: At Wilson on U. S. Highway 40, west side Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Shippensburg formation (Pinesburg member) in Pennsylvania: In field on north side of railroad, $2\frac{1}{2}$ miles southwest of Marion, Chambersburg (15') Quadrangle.

Sevier formation (sandstone No. 5 of Neuman) in Tennessee: 0.57 mile southwest of Rock Branch, Kinzel Springs (T.V.A. 148-NE) Quadrangle.

Discussion.—In general this species is characterized by its transverse form in most of the examples observed and by the bifurcation of the ribs particularly on the flanks. *Dinorthis quadriplicata* is regarded as a synonym of *D. transversa*, perhaps as one end member of a variable species. The type specimen of *D. quadriplicata* differs from the average specimen of *D. transversa* in being less wide proportionately and in having the median costae strong and unbifurcated. Many specimens in the collection are intermediate between this form and the type of *D. transversa*, which is quite wide and in which the median costae show some bifurcation. As most of the specimens lie between these two extremes it is believed *D. transversa* and *D. quadriplicata* belong to the same species.

The species is a very variable one showing extremes of ornamentation as well as of outline. The costae of the flanks in general always show some bifurcation. The large costae of the median region of both valves may or may not show bifurcation, but more specimens do show it than not.

DINORTHIS TRANSVERSOIDES Cooper, new species

Plate 6I, E, figures 23-28

Small, attaining about half the size of *D. transversa* which it resembles; pedicle valve nearly flat in lateral profile but with the umbonal region slightly swollen; anterior profile nearly flat; sides rounded, anterior margin truncated; median region nearly flat; anteromedian area gently sulcate and occupied by a fascicle of costae larger than those on the bounding areas; flanks very gently convex; posterolateral areas deflected slightly toward the brachial valve.

Brachial valve strongly convex in lateral profile with the greatest convexity in the median region; anterior and posterior slopes steep and nearly equal in length; anterior profile strongly convex; umbo sulcate, sulcus originating at the beak and extending to the anterior margin, narrow and shallow throughout its length; flanks bounding sulcus and lateral slopes inflated; posterolateral extremities swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 12.7 | ? | 16.0 | 12.9 | ? |
| Paratype (" " 110341a).... | 12.6 | ? | 17.5 | 15.2 | ? |
| " (brachial valve 110341c).... | ? | 13.0 | 16.3 | 12.4 | 3.7 |
| " (" " 110341d).... | ? | 12.6 | 16.2 | 12.7 | 3.9 |

Types.—Holotype: 110341b; figured paratypes: 110341a,c,d.

Horizon and locality.—Dryden formation in Tennessee: 1 mile west of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle.

Discussion.—In ornamentation and outline this species is very much like *D. transversa* but it differs in having a much more convex brachial valve. Young specimens of *D. transversa* comparable to the adults of *D. transversoides* have a much less convex brachial valve than that of the latter species.

DINORTHIS VENUSTA Cooper, new species

Plate 58, A, figures 1-3; plate 71, H, figures 41-50

Shell of about medium size for the genus, wider than long; subrectangular in outline; cardinal extremities obtuse; sides broadly rounded; anterior somewhat truncated; anterior commissure broadly uniplicate; surface strongly costate, about 34 on a large specimen; costae narrowly rounded in the young stages but becoming broad and low anteriorly.

Pedicle valve unevenly convex in lateral profile; the posterior half gently convex but the anterior half flattened; anterior profile flat; umbonal region gently swollen in the posterior half; anterior half gently depressed to form a faint but wide sulcus; lateral areas flattened except for the posterolateral extremities which are deflected slightly toward the brachial valve; interarea short, strongly apsacline; muscle field small but of the usual shape for the genus.

Brachial valve strongly convex in lateral profile with the maximum convexity in the median region; anterior profile strongly convex with the median region swollen and the lateral slopes steep; umbonal region well rounded; median region inflated; sulcus originating just anterior to the umbo, shallow and poorly defined to a point just anterior to the middle where it is elevated to form an ill-defined, broad fold; lateral slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 18.6 | 19.1 | 24.3 | 18.6 | 9.0 |
| Paratype (110286b) .. | 16.7 | 16.4 | 20.9 | 16.0 | 7.5 |

Type.—Holotype: 110286a; figured paratypes: 110286b, 116978a-c.

Horizon and locality.—Shaly bed in upper Red Knobs formation in Tennessee: 2 miles southeast of Kiser, Meadow (T.V.A. 139-NW) Quadrangle; 3 miles northwest of Madisonville, near fault, Sweetwater (T.V.A. 131-SW) Quadrangle.

Discussion.—This species is characterized by its compact, subrectangular outline and the strong costae. It is very similar to *D. atavoides* in its exterior details, but there are nevertheless many differences. *D. venustus* has a flatter pedicle valve which is not medianly inflated as in *D. atavoides*. Furthermore, the sides of the Red Knobs species are flatter and the sulcus is somewhat broader and more poorly defined. *Dinorthis venustus* is a less transverse shell than *D. atavoides*. The profiles of the brachial valves are similar, but that of *D. venus-*

tus is stronger in both lateral and anterior directions. The sulcus of the brachial valve of *D. atavoides* is stronger than that of *D. venusta*.

DINORTHIS VIRGINIENSIS Cooper, new species

Plate 59, B, figures 17-21

Shell unusually large for the genus, subrectangular in outline with the length less than the width; hinge narrow; cardinal extremities obtusely rounded; sides broadly rounded; front margin broadly truncated; surface multicostate, costae numbering about 4 in 5 mm. at the front margin.

Pedicle valve nearly flat to gently concave with the most concave part in the median region; umbonal region gently convex; fold originating at the umbo, low and inconspicuous throughout its length to the front margin; fold a narrow median fascicle of 3 primary costae expanding and increasing anteriorly by bifurcation and implantation. Flanks bounding fold gently concave; lateral and posterolateral regions flat. Interarea short, apsacline. Interior with long, sharply defined muscle field longitudinally rectangular in outline but with the anterior margin deeply indented; adjustor scars prominent; diductor scars long, oblique, sharply pointed at the anterior ends; adductor ridge elevated; pallial marks not strongly impressed.

Brachial valve fairly strongly convex in lateral profile with the maximum convexity at about the middle; anterior profile strongly and broadly convex, with the top somewhat flattened but with short, steep slopes to the sides; broadly sulcate; flanks bounding sulcus swollen; posterolateral slopes short and steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 29.9 | 30.4 | 38.7 | 29.0 | 11.5+ |
| Paratype (pedicle valve 116980b).... | 26.0 | ? | 34.0 | 29.0 ? | ? |

Types.—Holotype: 116979; figured paratypes: 116980a,b; unfigured paratypes: 116980c,d.

Horizon and locality.—Edinburg formation (50 to 75 feet above cherty bed of Lincolnshire) in Virginia: From a quarry on the north side of U. S. Highway 33, 1 mile west of the junction with Virginia Highway 613, 4 miles west of Dale Enterprise, Harrisonburg (15') Quadrangle; 500 to 600 feet above the "Lenoir" on Colliers Creek on Virginia Highway 251, $\frac{1}{2}$ mile north of the junction with Virginia Highway 612, 6 miles west-southwest of Lexington, Rockbridge County.

Discussion.—This is the largest species of *Dinorthis* at present known. The ornamentation of the pedicle valve indicates clearly that it is related to *D. transversa*. It differs in its great size and much less transverse outline.

DINORTHIS WILLARDI Cooper, new species

Plate 59, A, figures 1-16

Shell large for the genus, wider than long with obtusely rounded cardinal extremities and broadly rounded lateral and anterior margins. Anterior commis-

sure broadly arched toward the brachial valve. Hinge width equal to about two-thirds the width. Brachial valve shallow. Pedicle valve flattened, giving the species a compressed appearance. Surface marked by simple, unbifurcated costae, about 36 in number. Interspaces generally wider than the width of the costae, which are narrowly rounded to subcarinate.

Pedicle valve with narrowly swollen umbo occupying the posterior quarter and a prominent narrow beak; posterolateral slopes nearly flat and broad, varying to slightly convex where the cardinal extremities are bent toward the brachial valve. Median and anteromedian portions nearly flat to gently concave. Anterolateral areas nearly flat. Interarea very short, varying from apsacline to nearly procline.

Brachial valve moderately convex in lateral profile with the greatest convexity located in the posterior half; sulcus variable, when present originating at the beak and extending to the anterior margin where it is nearly merged in the general convexity. Sulcus usually occupied by 2 or 3 costae. Median half of valve gently swollen; posterolateral slopes moderately steep; anterior slope gentle; cardinal extremities deflected slightly toward the brachial valve. Interarea apsacline, arched over pedicle valve interarea.

Interior with pedicle muscle area small and brachial cardinalia delicate for such a large species.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 20.0 | 20.6 | 27.6 | 19.6 | 6.0 |
| Paratype (116981a) .. | 24.7 | 26.2 | 35.3 | 27.3 | 6.2 |
| “ (116981b) .. | 23.0 | 24.0 | 33.0 | 24.2 | 5.4 |

Types.—Holotype: 116981c; figured paratypes: 116981a,b, 116982a, 116983b, c, 117988a; unfigured paratypes: 116981d, 116982b, 116983a, 117988b-e.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 1 mile southeast of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 10 miles north of Knoxville and 2 miles northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; 1 mile north of Wilson Post Office, Briceville (30') Quadrangle; 2 miles southwest of Hall Crossroad, northwest quarter center subquad., Fountain City (T.V.A. 146-SW) Quadrangle; Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; Evans Ferry, U. S. Highway 25E, $\frac{3}{4}$ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; south of first bridge north of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; southwest quarter of the northwest subquad; 0.4 mile east of Red Hill, Avondale (T.V.A. 162-SW) Quadrangle on road to Thorn Hill; 2.1 miles southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle.

Same formation in Virginia: 1 mile west of Rye Cove; Speers Ferry; $\frac{1}{2}$ mile northeast of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species is distinguished by its large size and its direct un-

bifurcated costae. In these respects it resembles *D. atavoides* but differs in its more slender lateral profile, details of the ornamentation, and a differently proportioned pedicle valve which has much less depth than that of *D. atavoides*.

Genus VALCOUREA Raymond, 1911

Valcourea RAYMOND, Ann. Carnegie Mus., vol. 7, p. 239, pl. 35, figs. 15-19, pl. 36, fig. 1, text fig. 12, 1911; *Valcourea* (part) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 97, 1932.

The specimens described herein permit a reevaluation of the genus *Valcourea*. The description of the genus offered by Schuchert and Cooper in 1932 includes two groups of shells now separated under the names *Campylorthis* and *Chaulistomella*. These two genera hitherto included in *Valcourea* generally occur in later strata than those containing *Valcourea*, and as far as known the three do not occur together.

As repeatedly pointed out, *Valcourea* is a member of the *Dinorthidae*, retaining many primitive characters, and is probably the earliest known member of the family. External as well as internal features distinguish *Valcourea* from other members of the family. A pseudodeltidium and chilidial plates are constant features in all known species. Another feature constant in all species described herein is the more or less prominent, narrow, carinate fold that originates on the umbo of the pedicle valve and extends for a greater or less distance toward the anterior margin. This fold is most pronounced in the earliest members such as *V. intracarinata* and *V. strophomenoides* but is not very marked in an undescribed species (*Valcourea* sp. 2) from the Lincolnshire limestone of Tennessee. Corresponding to the fold of the pedicle valve is a more or less deep and long sulcus extending from the umbo of the brachial valve to the middle or beyond. When this sulcus is deep, it helps to emphasize and heighten the median ridge inside the brachial valve.

Inside the pedicle valve perhaps the most characteristic generic feature is the more or less strongly developed subperipheral rim which is a common feature of convexi-concave shells. This rim may be strongly thickened or may be only poorly developed. A negative feature of the genus is the lack of preservation of the pallial marks. The course of these sinuses is usually well marked in many members of the *Dinorthidae*, but only a few specimens of *Valcourea* have been seen that show any details of them. Such a specimen is *Valcourea* sp. 2 (110257) which shows the strong trunks of the vascula media originating at the anterior ends of the diductor impressions. These bifurcate almost exactly at their point of origin, the inner branches extending anteromedially and the outer ones extending slightly anterolaterally. Both sets of trunks are directed chiefly in an anterior direction unlike other members of the *Dinorthidae* in which the bifurcated branches extend anteromedianly and posterolaterally.

In the brachial valve the feature of generic importance is the cardinal process. This has a short and stout shaft but a prominent myophore. Generally the myophore is trilobed, the amount of lobation depending on the age of the speci-

men. The median lobe always bears a strong carina, a feature not present in closely related genera such as *Multicostella* and *Campylorthis*.

As far as present knowledge goes, *Valcourea* typifies the Marmor, Ashby, and lower part of the Porterfield stages. It appears first in the upper part of the Upper Pogonip of Nevada, is abundant in the Crown Point formation of New York, the Lenoir of Tennessee, the Lincolnshire and Whistle Creek formations of Virginia. The stratigraphically highest specimens known occur in the lower part of the Bromide of Oklahoma, the lower Eureka of Nevada, and the Long Point series of Newfoundland. The genus is thus an excellent guide to a narrow band of the geological column.

VALCOUREA ANGULATA (Phleger)

Plectambonites angulatus PHLEGER, Bull. S. California Acad. Sci., vol. 32, pt. 1, p. 17, pl. 1, fig. 1, 1933.

Horizon and locality.—Barrel Spring formation California: In Barrel Spring Canyon, Inyo Mountains.

VALCOUREA AUSTRINA Cooper, new species

Plate 75, B, figures 6-27

Valcourea strophomenoides BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 41, pl. 73, figs. 1-8, 1942.

Shell fairly large for the genus; hinge forming the widest part; cardinal extremities acute, occasionally auriculate. Anterior commissure broadly sulcate. Lateral margins faintly convex, sloping anteromedially. Anterior margin broadly rounded. Surface multicostellate, with 17 to 19 costellae in 5 mm. at the front margin of a valve 13 mm. long. Costellae narrowly rounded, strongly elevated.

Pedicle valve gently convex in the posterior third to half; gently to moderately deeply sulcate in the anterior half to two-thirds. Fold short, narrow, subcarinate, extending to about the middle of the valve where it is lost. Anteromedian sector depressed into a sulcus varying in depth on different individuals from barely perceptible to moderately deep. Flanks on each side of fold slightly convex in posterior half; flanks on each side of sulcus in anterior portion flat to gently concave. Cardinal extremities slightly depressed toward the brachial valve. Interarea short, strongly apsacline. Pseudodeltidium short.

Brachial valve moderately and evenly convex in lateral profile; in anterior profile the valve is humped up in the middle but flattens somewhat to the margins by a gentle descent. Sulcus, short, shallow, inconspicuous in most cases, becoming obsolete or faint in some specimens anterior to the middle. Anterior half to third thrown into a low, broad fold corresponding to the broad pedicle sulcate region. Flanks bounding fold and sulcus gently convex. Area between flanks and deflected cardinal extremities gently concave.

Muscle field of pedicle valve large, subrectangular at the front; diductor tracks large. Subperipheral rim strong.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.5 | 12.9 | 17.9 | 19.6 | 3.9 |
| Paratype (110195a) .. | 14.5 | 14.4 | 20.5 | 23.6+ | 4.2 |
| " (116965b) .. | 17.3 | 16.9 | 22.2 | 22.7 | 7.9 |

Types.—Holotype: 98177a; figured paratypes: 98177b,d,e, 110195a, 116965a, b; unfigured paratypes: 98177c,f-h, 110195b.

Horizon and locality.—Whistle Creek formation in Virginia: 1½ miles northwest of Lexington; Brushy Hills, on the road to Lexington; on U. S. Highway 60, 100 yards southeast of Whistle Creek, 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Ellett formation in Virginia: Ellett, Lusters Gate, Blacksburg (15') Quadrangle.

Discussion.—*Valcourea austrina* is characterized by a moderately strong median fold on the pedicle and a shallow but well-defined sulcus in the brachial valve, but both of these features are generally obsolete at the front of the adult shell. This species attains a fairly large size, almost the largest at present known. In this respect it resembles *V. deckeri* from the Tulip Creek formation in Oklahoma but differs in the more pronounced development of the fold and sulcus, the greater depth to the concave portions of the pedicle valve, and a less evenly convex brachial valve. The pedicle muscle area of the Whistle Creek species is squarer across the front than that of *V. deckeri* in which the diductor impressions are somewhat elongated. This species resembles *V. ventrocarinata* in the general form of the valves but differs in having a less concave pedicle valve and in having a less well developed fold and sulcus.

VALCOUREA BREVICARINATA Cooper, new species

Plate 75, A, figures 1-5

Shell of about medium size for the genus, wider than long with the hinge forming the widest part. Cardinal extremities acutely alate; sides sloping medially; anterior margin somewhat narrowly rounded. Costellae narrowly rounded, of unequal size, about 15 in 5 mm. at the front of a valve 12 mm. long.

Pedicle valve gently concave in lateral profile. Umbonal region marked by a narrow but short carina that extends indistinctly to the middle of the valve where it is lost in the general concavity. Median and lateral regions moderately concave; cardinal extremities somewhat flattened, large specimens tending to develop a narrowly rounded, sulcate front. Interarea short, strongly apsacline.

Brachial valve fairly strongly convex in lateral profile with the greatest convexity in the median region; anterior profile broadly convex but somewhat narrowly rounded in the median region. Umbonal region sulcate, the sulcus short and narrow. Sulcus disappearing on the somewhat inflated median area and not extending anterior to the middle. Flanks bounding sulcus slightly convex, and slopes to cardinal extremities gentle. Anterior slope moderately steep but becoming less inclined posterolaterally toward the cardinal extremities.

Pedicle interior with margin thickened slightly. Muscle area small and delicate with elongate diductor impressions. Pallial trunks not impressed. Brachial interior with short and narrow median ridge and small, delicate cardinalia.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.8 | 12.3 | 16.4 | ? | 2.4 |
| Paratype (pedicle valve 110248a)..... | 12.3 | ? | 14.6 | 16.8+ | ? |
| “ (brachial valve 110248b).... | ? | 12.0 | 15.8 | 20.0 ? | 3.0 |

Types.—Holotype: 110248c; figured paratypes: 110248a,b; unfigured paratypes; 110248d,e.

Horizon and locality.—Upper part of the Arline formation in Tennessee: North side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville; 100 yards southwest of Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 1,500 feet south of the mouth of Burnett Creek, Shooks Gap (T.V.A. 147-NE) Quadrangle.

Discussion.—This species is characterized by the shortness of the median carina and corresponding sulcus. Both these features are confined chiefly to the umbonal region and do not extend past the middle of either valve. In this respect the species differs from *V. ventrocarinata* which it otherwise resembles. It differs from *V. austrina* in having a more concave pedicle valve, a brachial valve with a somewhat more inflated median region, and with more prominent diversity of costellae in the ornamentation. *V. brevicarinata* differs from *V. obscura*, from the Lenoir formation, in having a more pronounced carina, finer costellae, deeper pedicle valve, and more convex brachial valve.

VALCOUREA DECKERI Cooper, new species

Plate 74, A, figures 1-14

Shell moderately large, wider than long with the hinge usually forming the widest part. Cardinal extremities varying from an acute angle in the young to nearly a right angle in old adults. Lateral margins varying from nearly straight to strongly oblique. Anterior margin broadly rounded. Surface multicostellate, 17 or 18 costellae in a distance of 5 mm. at the front margin of the holotype. Scattered costellae larger than those surrounding them often present.

Pedicle valve only slightly convex in the posterior one-quarter to one-third; gently concave in the front two-thirds to three-quarters. Fold narrow, moderately strong in the umbonal region, faint but perceptible from there to the front margin. Lateral regions slightly concave. Cardinal extremities slightly deflected toward the brachial valve. Interarea strongly apsacline to catacline. Pseudodeltidium narrow, long.

Brachial valve with the maximum convexity at about the middle. Umbogently concave. Sulcus narrow at the umbo, widening anteriorly and reaching the anterior margin; very shallow in the anterior third. Flanks bounding sulcus moderately swollen. Slopes to cardinal extremities gentle.

Interior: Pedicle muscle area with the diductor tracks extended anterior to the adductor track; pallial impressions not well developed. Brachial valve with stout cardinal process having a thick shaft and wide trilobed myophore. Central lobe of myophore with strongly elevated carina.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.5 | 17.5 | 23.3 | 22.1 | 5.1 |
| Paratype (110208d) .. | 13.9 | 13.9 | 20.3 | 23.1 | 3.7 |
| " (110208e) .. | 11.3 | 10.7 | 16.5 | 21.5 | 3.1 |
| " (110216b) .. | 15.0 | 15.0 | 20.5 | 23.8 | 4.6 |

Types.—Holotype: 110208a; figured paratypes: 110208b,c,e, 110211b,c, 110212a,b; unfigured paratypes: 110208d, 110211a; measured paratype: 110216b.

Horizon and locality.—Tulip Creek formation in Oklahoma: Beside road 1½ miles west of Nebo, SE¼SW¼ sec. 22, T. 2 S., R. 3 E.; valley of West Spring Creek, 3 miles east of Pooleville, Murray County.

Discussion.—This species attains a large size for the genus. In outline it varies considerably according to its age. In general the younger forms are much extended at the hinge, but the cardinal extremities of the older specimens are more nearly a right angle. Some young forms occur without alate extremities, a condition believed to be due to crowding in growth. This species resembles another large form occurring in the Whistle Creek formation of the Appalachians, *V. austrina*, but differs in possessing a flatter pedicle valve and shorter, less strongly developed fold and sulcus.

VALCOUREA INTRACARINATA Ulrich and Cooper

Plate 73, A, figures 1-4

Valcourea ? *intracarinata* ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 125, pl. 21C, figs. 9-12, 1938.

When this species was originally described its assignment to *Valcourea* was questioned. At that time the strong carina on the median lobe of the cardinal process was not known to be a distinctive feature of the genus. This carina, as well shown herein, is a generic character in Marmor and later specimens, but absent from a group of post-Marmor shells formerly placed in *Valcourea* but now referred to *Campylorthis*.

This species is especially distinguished by its small size, great width, strong median ridge inside the brachial valve, and the deep median sulcus. It is perhaps the earliest known species of the genus.

Types.—Holotype: 92852f; paratypes: 92852a-e,g-i; additional specimens: 110226.

Horizon and locality.—Upper part of Upper Pogonip group (*Valcourea* zone) in Nevada: In Ikes Canyon on the east side of the Toquima Range, Roberts Mountains (1°) Quadrangle.

VALCOUREA OBSCURA Cooper, new species

Plate 76, A, figures 1-10

Shell of about medium size for the genus, wider than long, with the hinge forming the widest part. Cardinal extremities generally acute to alate. Lateral margins gently convex; anterior margin broadly rounded. Surface marked by subangular costellae separated by interspaces wider than the costellae. About 13 costellae in 5 mm. at the front margin of a shell 8 mm. long.

Pedicle valve gently concave with the most concave part slightly anterior to the middle. Umbo carinate; carina short and narrow, indistinctly extending to the anterior margin as a slight elevated area. Posterolateral areas flattened. Interarea strongly apsacline.

Brachial valve strongly convex in lateral profile but broadly convex in anterior profile. Umbo marked by a narrow and shallow sulcus that is extended anterior to the front margin where it has widened considerably but occupies only about 2 mm. Flanks bounding sulcus somewhat inflated. Anterior slope moderately steep.

Pedicle interior with stout dental plates, the usual muscle field for the genus, but poorly defined pallial marks. Brachial interior with stout median ridge extending to about the middle. Brachioophores small but stout.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------|--------|-------|-------------|-----------|
| Holotype | 10.8 | 14.4 | 16.3+ | 3.0 |
| Paratype (110254d) | 8.3 | 13.0 | 14.3 | 2.5 |
| “ (110254c) | 8.9 | 15.5 | 14.3+ | 3.5 |
| “ (110254a) | 9.4 | 14.9 | 16.3+ | ? |

Types.—Holotype: 110254e; figured paratypes: 110254d, 116966; unfigured paratypes: 110254a-c.

Horizon and locality.—Lenoir formation in Tennessee: 2 miles south of Philadelphia; small quarry between the Southern Railroad tracks and U. S. Highway 11, 1½ miles southwest of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle.

Discussion.—This species is suggestive of *V. transversa* but differs in being less wide and in possessing stronger costellae. Its smaller size and less deeply concave pedicle valves with poorly developed carina distinguish the species from *V. ventrocarinata*. The smaller size and stronger costellae distinguish this species from *V. austrina*, and the latter character serves to differentiate it from *V. semicarinata* and *V. brevicarinata*.

VALCOUREA PLANA Cooper, new species

Plate 72, C, figures 14-21; plate 73, C, figures 15-22

Outline semielliptical with the hinge forming the widest part, sides sloping medially and the anterior margin somewhat narrowly rounded. Costellae narrowly rounded and separated by interspaces wider than the costellae, about 15 or 16 in the space of 5 mm. at the front margin of the holotype.

Pedicle valve nearly plane or gently concave in lateral profile. Fold low and narrowly rounded, originating on the umbo and extending anteriorly for about two-thirds to three-fourths the length where it disappears in a short and shallow sulcus that depresses the front of the valve. Lateral areas nearly flat. Interarea short and apsacline.

Brachial valve evenly and moderately convex in lateral profile; slightly more convex but broader in anterior profile. Sulcus not deeply impressed and extending to about the middle or anterior third. Entire valve gently inflated and with long moderately steep slopes to the anterior and lateral margins.

Pedicle interior with the usual muscle area having elongate diductor impressions but a fairly wide and large adductor track. Pallial marks occasionally deeply impressed. Median ridges inside brachial valve strong, fairly elevated, and extending slightly anterior to the middle.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--|--------|-------|-------------|-----------|
| Holotype | 12.4 | 19.7 | ? | 2.9 |
| Paratype (pedicle valve 116968b) | 9.0 | 15.5 | 20.6 | ? |
| " (brachial valve 116968a) | 10.0 | 17.9 | 22.4 | ? |

Types.—Holotype: 116967; figured paratypes: 110265a,c; 116968a,b, 117994a; unfigured paratypes: 110265b,d-f, 116969, 117994b-g.

Horizon and locality.—Yellow limestone overlying 25-foot sandstone at base of Eureka group, Roberts Mountains (1°) Quadrangle in Nevada: 2 to 3 miles north of Martin Ranch; on crest of Antelope Range, 3 miles south of Nine Mile Canyon; saddle just north of hill 8167, Martin Ridge, Monitor Range.

Discussion.—No other species is quite like this one in having such a flat pedicle valve. This character is approximated by *V. austrina*, but that is a larger species than the Nevada one and differently ornamented. *Valcourea plana* occurs with abundant specimens of *Sowerbyites*, which help to fix its age as about that of the Lincolnshire formation of Virginia and Tennessee and the basal part of the Bromide in Oklahoma.

VALCOUREA SEMICARINATA Cooper, new species

Plate 70, A, figures 1-10

Valcourea strophomenoides BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 41, pl. 73, figs. 9, 10, 1942.

Shell of about medium size for the genus, wider than long with the hinge usually forming the widest part; cardinal extremities varying from alate to nearly a right angle. Lateral margins oblique, anterior margin broadly rounded. Surface multicostellate, costellae about 3 or 4 to the millimeter at the front margin.

Pedicle valve gently convex in lateral profile in the posterior half but gently to moderately convex in the anterior half. Umbo carinate, the carina low and extending to about the center where it is lost in a broad shallow depression or continued to the front margin as a broader but very faint undulation. Areas bounding carina gently concave but the posterolateral areas flattened and bent

slightly toward the brachial valve. Beak slightly protruding beyond posterior margin. Interarea strongly apsacline; pseudodeltidium narrowly convex and short. Muscle area with the usual form for the genus, about as long as wide; the diductor impressions often bounded on both sides and at the front by low thickenings of callus. Ovarian impressions small.

Brachial valve flattened or gently concave in lateral profile in the posterior third but gently convex in the anterior two-thirds; in anterior profile broadly convex with the sides descending in long gentle slopes and the median region slightly sulcate. Umbo sulcate, the sulcus extending to about the middle as a narrow and fairly deep depression, but anterior to the middle it may be lost nearly completely or continued as a shallow but wider depression nearly to the front margin, although rarely attaining that end. Anterolateral areas bounding the sulcate region gently swollen; posterolateral slopes gentle with the region just anterior to the cardinal extremities slightly concave. Median elevation of the brachial interior extending to the middle but not strongly elevated. Cardinal process small, with a strong median carina. Brachial processes short.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-------|-------------|-----------|
| Holotype | 9.3 | 13.0 | 15.5 | 2.5 |
| Paratype (pedicle valve 110228e)..... | 10.6 | 14.0 | 17.5 | ? |
| " (110228a) | 7.3 | 12.6 | 15.3 | 2.2 |

Types.—Holotype: 110228d; figured paratypes: 98179, 110228e,g; unfigured paratypes: 110228a-c,f.

Horizon and locality.—Upper part of the Arline formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species is most similar to *V. brevicarinata* but differs in having finer costellae, a different outline, and stronger fold. Furthermore, *V. semicarinata* is a flatter shell and has the posterior of the brachial valve concave or somewhat flattened.

VALCOUREA STROPHOMENOIDES (Raymond)

Plate 74, B, figures 15-25

Plaesiomys strophomenoides RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 370, 1905.

Valcourea strophomenoides RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 240, pl. 35, figs. 15, 17, 19 (not figs. 16, 18); pl. 36, fig. 1, text fig. 12, 1911.

The young of *Valcourea strophomenoides* generally possess a wide hinge and acute cardinal extremities. As the shell increases in age and additions are made to the margins, these tend to elongate the shell and give it a more quadrate form. The adult is thus one in which the width slightly exceeds the length and the cardinal extremities are approximately a right angle or are slightly obtuse.

The umbo of the pedicle valve is strongly carinate, but the carina is continued as a fold for about one-half to three-quarters the length of the valve. As a rule the fold is lost in the front quarter which often is bent noticeably in an anteropedicad direction. The sulcus of the brachial valve is deepest at the umbo

where the fold of the opposite valve is the strongest, and becomes shallower at the middle and front. At the front margin of an adult specimen the sulcus is exceedingly faint or absent.

The surface of this species is finely multicostellate, but the costellae are of unequal size and appear in at least 3 generations by intercalation.

Measurements in mm.—Holotype, length 12.0, brachial length 10.8, width 12.9, hinge width 11.8.

Types.—Holotype: Carnegie Mus. 5450; figured paratypes: Carnegie Mus. 5466, 5467, 5492.

Horizon and locality.—Crown Point formation in New York: Chazy, Rouses Point (15') Quadrangle; Valcour Island and Crown Point, Plattsburg (15') Quadrangle. Same formation in Vermont: At Fort Cassin, Port Henry (15') Quadrangle.

Discussion.—The type specimens show this species to be a small form about one-third wider than long and with fine costellae covered by fine elevated fila. The brachial interior figured by Raymond (pl. 35, figs. 16, 18) and said to belong to this species has the characters of *Multicostella platys* and is a larger and more coarsely costellate shell.

Valcourea strophomenoides is characterized by its small size, somewhat rectangular outline, small muscle area, and shallow brachial valve. It differs from *V. obscura* in having less angular cardinal extremities, finer costellae, and a shorter, less prominent carina on the pedicle valve.

VALCOUREA TENUIS Cooper, new species

Plate 76, D, figures 18-29

Shell of about medium size for the genus, wider than long, transverse in young stages; hinge forming the widest part; sides nearly straight, oblique; anterior margin broadly rounded. Anterior commissure rectimarginate. Surface costellate, costellae separated by spaces about equal in width to the width of a costella; about 20 costellae in 5 mm. at the front margin.

Pedicle valve gently concave in lateral profile, most concave in the median region; fold low, originating at the beak and extending distinctly to a point near the middle; anterior to that point fold low and indistinct to the anterior margin. Flanks bounding fold gently concave; posterolateral extremities flattened. Interarea short, apsacline; pseudodeltidium short. Interior with muscle field not reaching the middle, subperipheral rim strong.

Brachial valve gently convex in lateral profile; broadly and gently convex in anterior profile; sulcus deep, narrow, deeply entrenched in the posterior two-thirds, indistinctly defined in the anterior third; flanks bounding sulcus narrowly but gently folded; posterolateral areas depressed, slopes short and gentle. Interior with median ridge strongly defined nearly to the front margin; brachio-phores short, supported by callus; cardinal process with a long and stout shaft.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 6.9 | 6.9 | 10.8 | 12.3 | 1.2 |
| Paratype (116970c) | 9.0 | 9.6 | 13.1 | 15.9 | 1.1 |
| “ (pedicle valve 116970j) | 7.7 | ? | 12.6 | 15.4 | ? |

Types.—Holotype: 116970e; figured paratypes: 116970a,b,d,f,g,i,j; unfigured paratypes: 116970c,h.

Horizon and locality.—Tulip Creek formation (152 feet above the basal sand) in Oklahoma: On the first creek east of U. S. Highway 77, SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County; West Spring Creek, 2 $\frac{1}{2}$ miles east of Pooleville, Murray County.

Discussion.—This species occurs in abundance in a few places. Generally young transverse specimens are far more abundant than adults. In the young form the species suggests *V. transversa*, but it is generally smaller and less convex.

VALCOUREA TRANSVERSA Cooper, new species

Plate 72, D, figures 22-31; plate 76, B, figures 11-14

Shell of about medium size for the genus; wider than long with the length ranging from one-half to two-thirds the width at the hinge; hinge wide, forming the widest part, often mucronate and with acute extremities; sides oblique, nearly straight; anterior margin broadly curved; anterior commissure rectimarginate; surface marked by costellae of unequal size, the large ones scattered among the finer ones, 3 or 4 in 1 mm. at the front margin; costellae crossed by strong, elevated concentric fila about 8 to the millimeter.

Pedicle valve evenly and fairly deeply concave, with the greatest depth in the median region; umbo sharply folded; fold low, distinct to middle but obscure from there to anterior margin; posterolateral extremities just anterior to posterior margin slightly sulcate; posterior margin forming a thickened and elevated rib; interarea long, strongly apsacline; pseudodeltidium long and strongly elevated.

Brachial valve unevenly convex in lateral profile, the posterior third flattened to slightly concave, median third strongly convex, anterior third gently convex; anterior profile broadly convex with the median region narrowly sulcate; umbo flat to gently concave, fairly deeply and narrowly sulcate; sulcus extending for two-thirds the length but disappearing on the anterior slope; median region inflated; flanks somewhat depressed and with gentle slopes.

Pedicle interior with deeply impressed muscle area with thickened margins, extending nearly to middle; brachial interior with stout brachiophores supported by callus deposit; cardinal process with stout shaft and high-crested myophore.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.8 | 10.2 | 15.2 | 19.0 | 2.5 |
| Paratype (116972b) | 11.4 | 11.4 | 17.7 | 18.5 | 3.5 |
| “ (116972a) | 11.9 | 11.9 | 17.5 | 19.6 | 3.6 |

Types.—Holotype: 116971; figured paratypes: 116972b,d, 110277b; unfigured paratypes: 110277a,c,d, 116972a,c.

Horizon and locality.—Lower Bromide (Mountain Lake member—small *Valcourea* bed) in Oklahoma: On Oklahoma Highway 99, 3 miles south of Fittstown, Pontotoc County; top of zone 7, Rock Crossing of Hickory Creek, center sec. 35, T. 5 S., R. 1 E., Carter County; U. S. Highway 77, NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County; Falls Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec 33, T. 1 S., R. 2 E., Murray County; “reef” beds on west side Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; 49 to 66 feet above the Bromide sandstone on Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is characterized by its transverse form and the fine costellate ornamentation. It is not like any of the *Valcoureas* of the Appalachians. It differs from *V. deckeri* in its generally smaller size and wider outline.

VALCOUREA VENTRO-CARINATA (Butts)

Plate 71, C, figures 10-14; plate 73, B, figures 5-14

Strophomena ventro-carinata BUTTS, Alabama Geol. Surv., Special Rep. 14, pl. 16, figs. 16, 17, 1926.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 97, 1932.

Shell fairly large for the genus, subquadrate to subrectangular with the width slightly greater than the length; hinge forming the widest part; sides gently convex, oblique; anterior margin narrowly rounded; anterior commissure rectimarginate; surface costellate, costellae closely crowded, about 13 in 5 mm. at the anterior margin. Costellae crossed by closely crowded, elevated concentric fila, about 12 to the millimeter.

Pedicle valve fairly deeply concave with the most concave part in the anterior third; umbo prominently and sharply carinate; carina extended to the middle as a strong narrow fold, low and indistinct from the middle to the front margin. Areas bounding carina gently concave; interarea strongly apsacline.

Brachial valve strongly convex in lateral profile with the greatest convexity at about the middle; anterior profile fairly strongly convex but with the middle narrowly sulcate. Median region inflated; umbo somewhat flattened, sulcate; sulcus narrow and deep in the posterior half, shallower anteriorly to the front margin but distinctly visible; flanks bounding sulcus inflated; posterolateral and lateral slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (117992a)..... | 13.1 | 12.7 | 15.8 | 16.2 | 3.5 |
| “ (110246)..... | 12.4 | 11.9 | 16.9 | 17.6 ? | 3.5 |

Types.—Lectotype: 71498a; figured paratype: 71498b; figured hypotypes: 110246, 117992a.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile north of Pelham on U. S. Highway 31, Bessemer Iron District (15') Quadrangle; $\frac{1}{2}$ mile south of Newala, Montevallo (15') Quadrangle; Ragland Cement Company

Quarry, 3 miles south of Ragland, St. Clair County; junction of Cahaba Valley road with Bailey Gap road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles north-east of Newhope Church, Vandiver (15') Quadrangle.

Discussion.—This species is characterized by its subquadrate form, crowded costellae, and the strength of the fold and sulcus. It is suggestive of *V. austrina* from which it differs in its more concave pedicle valve, stronger pedicle fold, and much deeper sulcus.

This species also resembles *V. brevicarinata* which occurs at about the Little Oak equivalent in Tennessee (Arline formation) but differs in its stronger fold and sulcus and the more oblique lateral margins. It is also similar to *V. semicarinata* but differs in its stronger costellation, stronger fold and sulcus, and more robust form.

VALCOUREA sp.

As usual with any large collection a number of specimens cannot be placed in hitherto described species or in any of the new ones figured here. All the specimens are fairly large forms mostly poorly preserved.

Valcourea sp. 1 (pl. 73, E, figs. 26, 27): This is a very poorly preserved specimen (110203a) with a length of about 20 mm.; preserving only a trace of the usual carinate fold and with a strong sulcus at the front of the pedicle valve producing a nasute anterior. The brachial valve is strongly convex and has a narrowly pinched-up fold at the front. The specimen measures 26 mm. in width but is not complete on either side and must have been much wider. A smaller specimen (110203b) in the same lot measures: 16 mm. in length by 23.3 mm. The specimens were taken from the Lincolnshire formation in the Marcem Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle, Virginia. Figured specimen: 110203a.

Valcourea sp. 2 (pl. 73, D, figs. 23-25): Two pedicle valves, 110204 and 110257, of an unusually large and thick-shelled species, suggestive of *Campylorthis*, represent an undescribed species. However, a trace of a pseudodeltidium is preserved and a thickened subperipheral rim is present, features that link the specimens to *Valcourea*. The other and most striking feature of these specimens is the large size of the muscle area which in specimen 110257 extends anteriorly from the beak for two-thirds the length and occupies nearly a fourth of the inner area. Furthermore, the thickened, dichotomous proximal ends of the pallial trunks are well preserved. Specimen 110204 measures: Length 15.6 mm., width 20 mm., hinge width 26 mm. The specimens were taken from the Lincolnshire formation at Marble Bluff, 8 miles west-northwest of Loudon, Loudon (30') Quadrangle, Tennessee. Specimens of *Multicostella* from this locality are also very thick shelled. Figured specimen: 110257.

Valcourea sp. 3: This is represented by a lot of three specimens (110256) of a finely costellate species having a well-marked carinate pedicle fold and a narrow, deep brachial sulcus. The specimens suggest *V. austrina* but are more finely ornamented. They also have some resemblance to *V. deckeri* but are too poorly

preserved to make a good comparison possible. Cherty marble in the lower 50 feet of the Red Knobs formation, 3 miles southeast of Knoxville, Tenn.

Valcourea sp. 4: A single poorly preserved specimen (110202) measuring 18 mm. in length and 23 mm. wide, with fine costellae, strongly convex brachial valve having a sulcus extending nearly to the anterior margin, represents still another species. Costellae number 18 or 19 in 5 mm. at the front margin. The specimen is suggestive of *V. austrina* but is more convex and more finely ornamented. Arline formation, 1 mile southeast of Fowlers Mill, 10 miles southeast of Loudon, Loudon (30') Quadrangle, Tennessee.

Valcourea sp. 5: Another large species (116973a,b) similar to the preceding occurs in the Mountain Hill conglomerate of the Quebec City formation. It is 19.4 mm. long and 24.6 mm. wide. The maximum concavity is in the median region, but the valve is not deeply concave. The fold extends from beak to anterior margin. This is one of the largest Valcoureas yet seen but, of all those that have been described, is most suggestive of the Whistle Creek and Lincolnshire specimens.

Horizon and locality.—Quebec City formation, 400 to 500 feet south of Morin Building, Mountain Hill, Quebec.

Genus **MULTICOSTELLA** Schuchert and Cooper, 1931

Multicostella SCHUCHERT and COOPER, Amer. Journ. Sci., vol. 22, p. 244, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 98, 1932.

MULTICOSTELLA BURSA (Raymond)

Plate 64, C, figures 10-16

Hebertella bursa RAYMOND, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 294, pl. 1, fig. 7, 1928.

Multicostella whitesburgensis BUTTS, Virginia Geol. Surv. Bull. 52, p. 67, pl. 80, figs. 14-17, 1942.

Shell of about the usual size or large for the genus, slightly wider than long with the greatest width at about the middle. Hinge narrower than the greatest shell width or about equal to the midwidth. Cardinal extremities acutely angular to subalate. Lateral margins generally concave just anterior to the cardinal angle but broadly rounded anterolaterally; anterior margin broadly rounded. Anterior commissure rectimarginate to slightly uniplicate. Valves nearly equal in depth. Surface multicostellate; valves marked by 70 to about 84 costellae that appear in 3 generations by implantation.

Pedicle valve swollen in the midregion with moderately steep posterolateral and umbonal slopes but fairly gentle anterior slope. Umbonal region narrowly swollen, with beak narrow and sharply produced posteriorly. Swollen umbonal region continued anteriorly as an indistinct fold to about the middle. Anterior quarter to half bent gently in the direction of the brachial valve. Lateral profile with the greatest depth in the posterior half; the anterior profile forming a broad arch. Interarea of moderate length, strongly apsacline.

Brachial valve having the greatest convexity in lateral profile somewhat anterior to the middle, forming a low arch somewhat flattened at the middle in anterior profile. Umbo concave, with the concavity produced anteriorly as a very shallow and narrow sulcus to a point a short distance anterior to the middle. Median, anteromedian, and anterolateral areas moderately swollen with moderately steep slopes to the margins. Posterolateral slopes gentle. Interarea nearly as long as the pedicle one, gently anacline.

Interior: Pedicle muscle area about as long as wide and in length equal to about a third the length of the valve. Adductor track wide, slightly elevated anteriorly; diductor impressions long and narrow. Pallial trunks not strongly impressed. Median ridge of brachial valve low and short, equal in length to about one-third the length of the valve. Cardinal process short and stout; myophore not greatly thickened.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-------|-------------|-----------|
| Hypotype (pedicle valve 110371d)..... | 22.4 | 26.3 | 23.2 | 4.2 |
| " (110371e) | 23.7 | 26.7 | 22.8 | 5.4 |
| " (brachial valve 110371a).... | 24.3 | 27.3 | 23.2 | 5.5 |

Types.—Holotype: M.C.Z. 8597; figured hypotypes: 110371a,b,d,e, 110372a, b, 116984h; unfigured hypotypes: 110371c, 116984a-g.

Horizon and locality.—Chatham Hill formation in Virginia: Grayson Farm, 4 miles southwest of Bland, Bland County; 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Botetourt formation in Virginia: Near Dunkard Church, 7 miles west of Natural Bridge, Natural Bridge (15') Quadrangle; junction Virginia Highways 311 and 114, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle; about 1 mile northwest of Lexington, Lexington (15') Quadrangle; $1\frac{1}{2}$ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle.

Whitesburg formation in Tennessee: In the railroad cut at Summit Hill school, 1 mile southwest of Otes, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Discussion.—This species is known from a few specimens only: The holotype, which is preserved in the Museum of Comparative Zoology, Harvard; a few fine valves etched out of black limestone; and a few exfoliated specimens preserved in black limestone. The species is characterized by its strongly biconvex form, a hinge narrower than the greatest shell width, and fairly strong costellae. This species most closely resembles *M. convexa* but differs in the narrower hinge, somewhat squarer form, and lesser development of the sulcus of the brachial valve. *M. bursa* differs from *M. plicata* in the lesser number of costellae and possession of a smaller muscle area in the pedicle valve. *Multicostella whitesburgensis* Butts occurs at about the same horizon as *M. bursa* and has similar exterior characters to that species. It is therefore placed as a synonym of Raymond's species.

MULTICOSTELLA CONVEXA Cooper, new species

Plate 60, A, figures 1-19; plate 61, A, figures 1-6

Shell large, semielliptical in outline, a little wider than long, with the hinge slightly greater than the width at the middle. Cardinal extremities approximately a right angle, auriculate in the young. Lateral margins nearly straight in the adult; anterior margin broadly rounded. Anterior commissure faintly uniplicate in the adult. Surface multicostellate, costellae low, rounded, with interspaces equal in width to the width of the costellae; 4 to 5 costellae occupy a space of 5 mm. at the front of a large specimen.

Pedicle valve unevenly convex in lateral profile, the umbo moderately convex, the midregion flattened and the anterior third subgeniculate. Anterior profile broadly and gently convex. Beak and umbo narrowly swollen, but this folding extends only for a short distance. Umbonal slopes to the cardinal extremities gentle. Lateral, anterior, and midregions slightly swollen. Interarea slightly longer than the brachial interarea, slightly apsacline; beak pointed, incurved.

Brachial valve unevenly convex in lateral profile, the greatest convexity located in the midregion. Anterior profile broadly and moderately strongly arched. Sulcus shallow, narrow, poorly defined, located in the posterior half. Anteromedial and anterolateral portions moderately swollen. Slopes to cardinal extremities gentle, long. Cardinal extremities slightly deflected in direction of brachial valve. Interarea long, anacline.

Pedicle interior with the muscle field confined to the posterior third; dental plates nearly obsolete; ovarian impressions small. Brachial valve having cardinal process with a long, slender shaft, narrow myophore; lateral or secondary processes strongly developed in some specimens. Median ridge short.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 24.4 | 23.7 | 30.8 | 31.3 | 9.9 |
| Paratype (110386a) | 22.5 | 21.9 | 27.0 | 28.0 | 9.5 |
| " (116986a) | 23.0 | 22.0 | 28.3 | 28.5 | 10.4 |

Types.—Holotype: 110389a; figured paratypes: 110380a,b, 110385b-d, 110386a,b, 116986a,b; unfigured paratypes: 110380c, 110385a,e, 110386c, 110389b-j.

Horizon and locality.—Lower Bromide formation (Mountain Lake member) in Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E.; Mountain Lake, east half sec. 22, T. 2 S., R. 1 W.; Carter County. Dam in sec. 17, T. 2 S., R. 1 W., Murray County.

MULTICOSTELLA FASCICULATA (Butts)

Plate 56, C, figures 26-28; plate 71, D, figures 15-20

Dalmanella fasciculata (sic) BUTTS, Alabama Geol. Surv. Special Rep. 14, p. 116, pl. 26, figs. 3, 4, 1926.

Nine specimens additional to the type permit a fuller description of the species and correct generic assignment.

Shell of about median size for the genus; wider than long with the hinge narrower than the midwidth; sides rounded; anterior margin broadly rounded; anterior commissure rectimarginate; valves subequally convex; surface unequally costellate, the strong costellae scattered among the finer ones; about 3 costellae to the millimeter at the anterior margin.

Pedicle valve unevenly convex in lateral profile, the posterior half gently convex but the anterior half flattened; anterior profile with the median region narrowly folded with long, gentle and flat slopes to the margins; umbo narrowly swollen, the swelling continued anteriorly for about half the length as a low fold; flanks bounding fold depressed slightly and with gentle slopes to the extremities. Interarea moderately long, apsacline.

Brachial valve with a gently convex lateral profile; anterior profile broadly but gently convex and with the median region narrowly depressed; umbo sulcate, sulcus narrow and shallow, extending to about the middle where it becomes shallower and wider, nearly to disappear at the front margin; flanks bounding the sulcus somewhat swollen; posterolateral slopes long and gentle; interarea short and gently anacline.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.7 | 9.0 | 11.6 | 11.6 | 4.2 |
| Hypotype (116987) | 13.5+ | 13.0 | 17.2 | ? | 5.9 |

Types.—Holotype: 71493; figured hypotype: 116987.

Horizon and locality.—Little Oak formation in Alabama: On U. S. Highway 31, $\frac{1}{2}$ mile north of Pelham, 660 feet east of the intersection of main Cahaba Valley road with Helena road, Bessemer Iron District (15') Quadrangle; junction of Bailey Gap and Cahaba Valley roads, $1\frac{3}{4}$ miles northeast of Newhope Church, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., Vandiver (15') Quadrangle.

Discussion.—In size and form this species suggests *M. robusta*, but it is much more strongly costellate and the costellae are strongly fasciculate. It is possible that the specimens of this species so far available are in reality only young ones.

MULTICOSTELLA GERONTICA Cooper, new species

Plate 62, C, figures 15-20

Shell large, subquadrate in outline with the width greater than the length; cardinal extremities acutely angular, subauriculate. Valves subequal in depth and convexity, the brachial valve having slightly more depth than the pedicle valve. Lateral margins concave just anterior to the cardinal extremities or obliquely straight; anterior margin broadly rounded. Anterior commissure rectimarginate. Surface multicostellate, with 7 to 10 costellae in 5 mm. at the front of an adult.

Pedicle valve with the most convex part in the umbonal region, flattened anteriorly. Fold obsolete anterior to the posterior third. Anterior half and flanks very gently convex; slopes to cardinal extremities very gentle. Beak fairly large, protruding beyond the posterior margin. Interarea moderately long, curved, apsacline.

Brachial valve with a barely visible sulcus in the posterior half; front half gently convex; flanks gently convex; slopes to cardinal extremities short but gentle. In lateral profile the valve is gently convex with the maximum convexity near the middle.

Interior: Pallial marks of both valves well developed as elevated ridges. Cardinal process elongate, large.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 21.8 | ? | 16.6 | 28.6 | 4.1 |
| Paratype (110392e) | 21.7 | 23.3 | 27.4 | ? | 4.9 |
| “ (pedicle valve 110392g)... | 23.3 | ? | 29.3 | 29.0 | ? |
| “ (brachial valve 110392c) .. | ? | 21.6 | 26.7 | 23.4 | 3.7 |

Types.—Holotype: 110392f; figured paratypes: 110392a,c,g; unfigured paratypes: 110392b,d,e,h.

Horizon and locality.—Lincolnshire formation in Tennessee: Marble Bluff, 8 miles west-northwest of Loudon, Loudon (30') Quadrangle.

Discussion.—This species is characterized by its wide hinge and fine costellae together with the large and elongate muscle area of the pedicle valve and strong pallial marks of both valves. In form the species suggests *M. bursa* but is more strongly costellate. It does not possess the strong pedicle carination and deep sulcus of *M. plicata*.

MULTICOSTELLA PARALLELA Cooper, new species

Plate 61, C, figures 11-15

Shell of about medium size for the genus, wider than long but subquadrate in appearance; cardinal extremities approximately a right angle; sides nearly straight; anterior margin somewhat narrowly rounded; anterior commissure rectimarginate; lateral commissure slightly deflected toward the brachial valve; surface multicostellate, costellae numbering 10 in 5 mm. at the anterior margin.

Pedicle valve very gently convex in lateral and anterior profile; umbo narrowly swollen into a low and narrow fold that extends to the middle distinctly but is barely perceptible anterior to that point; flanks flattened and gently sloping to the margins. Interarea long, approximately catacline.

Brachial valve fairly strongly convex in lateral profile, broadly but moderately convex in anterior profile; interarea approximately orthocline, moderately long; umbo swollen; sulcus small and poorly defined; flanks and median half somewhat swollen and having about the same convexity; posterolateral slopes short and moderately steep; posterolateral extremities fairly strongly deflected.

Measurements in mm.—Holotype, length 22.7, brachial length 23.8, width 26.0, hinge width 24.2, thickness 8.7.

Types.—Holotype: 116989b; unfigured paratype: 116989a.

Horizon and locality.—Yellow limestone on 25-foot sandstone at base of Eureka group in Nevada: Ridge east of Martin Ranch, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by its parallel sides, the low convexity of the pedicle valve, and the fairly strong convexity of the opposite valve. In these respects it differs from all other described species of *Multicostella*.

MULTICOSTELLA PLANOSULCATA Cooper, new species

Plate 62, A, figures 1-5

Shell large for the genus, wider than long, subrectangular in outline; hinge slightly wider than the midwidth; cardinal extremities slightly acute; sides straight, slightly oblique; front margin broadly rounded; anterior commissure gently and broadly uniplicate; surface multicostellate, costellae approximately equal in width to the striae; 8 costellae in 5 mm. at the front margin.

Pedicle valve unevenly convex in lateral profile, the posterior half moderately convex, the anterior half flattened. Anterior profile broadly and gently convex. Umbo somewhat swollen, not narrowly plicated as in many species of the genus; fold indistinct on the posterior half, obsolete in the anterior half; front flattened and depressed; flanks flattened to gently swollen; posterolateral region depressed and deflected toward the brachial valve; posterolateral slopes long and gentle. Interarea short, curved, apsacline. Interior with short and narrow muscle field.

Brachial valve gently but somewhat unevenly convex, the greatest convexity at about the middle, the anterior somewhat flattened; anterior profile broadly and gently convex; umbo sulcate, sulcus short and narrow, disappearing at about the middle; median region gently swollen; flanks level with median region and sloping gently to the lateral and posterolateral areas.

Measurements in mm.—Holotype, length 22.6, brachial length 22.4, width 27.6, hinge width 28.0, thickness 8.6.

Types.—Holotype: 110423a; figured paratype: 110412a; unfigured paratypes: 110412b,c, 104423b-i.

Horizon and locality.—Arline formation in Tennessee: 1 mile east-northeast of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle; north side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is suggestive of *M. plicata* but differs in not having the strong median fold of the pedicle valve, the deep sulcus of the brachial valve. It is reminiscent of *M. quadrata* in size but is more strongly costellate, differently shaped, and somewhat less convex. Furthermore, the muscle field of *M. quadrata* is proportionately larger than that of the Friendsville species.

MULTICOSTELLA PLATYS (Billings)

Plate 68, A, figures 1-4

Orthis platys BILLINGS, Canadian Nat. Geol., vol. 4, p. 438, fig. 15, 1859; Geol. Canada, p. 129, fig. 54, 1863.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 218, 1892.—LESLEY, Geol. Surv. Pennsylvania, Rep. P. 4, p. 530, 1889.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 424, 1893.

Dinorthis platys (Billings) SCHUCHERT, U. S. Geol. Surv. Bull. 87, p. 216, 1897.

Placsiomys platys (Billings) RAYMOND, Ann. Carnegie Mus., vol. 7, p. 238, pl. 35, figs. 13-14, 1911.

Multicostella platys (Billings) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 98, 1932.

Like all species of *Multicostella* this one is also very variable in size and certain of the details of the surface. The type specimen (G.S.C. 1034) which is preserved in the Geological Survey of Canada collection is a fairly large specimen but is poorly preserved. Much of the exterior has been stripped from the shell, making it impossible to determine the details of the costellae exactly. The convexity of both valves is low and at the front of the pedicle valve the specimen is depressed to form a broad and shallow sulcus. The sulcus of the brachial valve is shallow and narrow and extends about to the middle of the valve. At the front of the brachial valve a low swelling corresponds to the sulcus of the pedicle valve. Some specimens show a clearly defined sulcus in the brachial valve extending from the beak to the anterior margin. Ten costellae may be counted in a distance of 5 mm. at the front margin of the holotype. Inasmuch as this specimen is much exfoliated, it is possible that the finest costellae of the latest generation are lost and cannot be counted. The holotype is 18.5 mm. long, 21 mm. wide, and 5.5 mm. thick. Specimens preserving the exterior show the costellae to be narrow, elevated, and bundled with ones of various sizes in several generations.

Types.—Holotype: G.S.C. 1034; figured hypotype: Carnegie Mus. 5467 (on same slab with *Valcourea strophomenoides*).

Horizon and locality.—Common in the Crown Point formation in New York: Crown Point, Port Henry (15') Quadrangle; Plattsburg and Valcour Island, Plattsburg (15') Quadrangle; Chazy, Rouses Point (15') Quadrangle.

Same formation in Vermont: On Isle La Motte, Rouses Point (15') Quadrangle.

St. Martin formation, Island of Montreal, Quebec, Canada.

Discussion.—This species is most like *M. saffordi* but is in general smaller in size and somewhat more quadrate. It is also suggestive of *M. plena* from which it differs in its stronger pedicle fold and brachial sulcus and its lesser convexity. The species may be a composite one because the holotype is stratigraphically younger than the New York specimens.

MULTICOSTELLA PLENA Cooper, new species

Plate 62, B, figures 6-14

Shell small for the genus, slightly wider than long, and with the greatest width at about the middle. Cardinal extremities acutely to obtusely angular, rarely auriculate. Both valves moderately convex, the brachial valve generally the deeper. Anterior commissure rectimarginate. Surface multicostellate, 10 to 12 costellae occupying a distance of 5 mm. at the front.

Pedicle valve unevenly convex in lateral profile, with the greatest convexity in the posterior half and the front half flattened or depressed. Fold nearly obsolete, best developed in the posterior half. Flanks flattened and sloping gently away

from the median region. Interarea slightly longer than the brachial one, curved, apsacline.

Brachial valve unevenly convex in lateral profile with a convex umbo but gently convex midregion and anterior region. Sulcus deepest in the posterior half, disappearing at about three-fourths the length from the beak. Flanks moderately swollen. Slopes to cardinal extremities moderately steep.

Interior with pedicle muscle field short and narrow. Diductor scars not widely divergent. Brachial valve having a small cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 14.0 | 13.8 | 15.8 | 13.7 | 6.5 |
| Paratype (110403d) | 15.4 | 14.5 | 16.4 | 13.0 | 7.9 |
| " (110402g) | 14.3 | 14.1 | 17.2 | 10.7 ? | 6.9 |
| " (110402f) | 15.3 | 14.4 | 16.1 | 12.8 | 6.9 |

Types.—Holotype: 110403e; figured paratypes: 110403b-d; unfigured paratypes: 110402a-e, 110403a,f; measured paratypes: 110402f,g.

Horizon and locality.—Arline formation in Tennessee: North side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is characterized by its small size (it and *M. fasciculata* Butts are the smallest known species), its relatively strong convexity, particularly of the brachial valve, rounded outline, and narrow hinge. In these respects it differs from known species.

MULTICOSTELLA PLICATA Cooper, new species

Plate 63, D, figures 22-29

Large for the genus, somewhat variable; wider than long with the greatest width at the hinge in well-preserved specimens; sides nearly straight or gently rounded; anterior margin broadly rounded; anterior commissure varying from slightly uniplicate to slightly sulcate; lateral commissure slightly deflected toward the brachial valve at the cardinal extremities; brachial valve having a slightly deeper profile than the pedicle one; cardinal extremities varying from slightly acute to slightly obtuse, occasionally slightly auriculate; surface multicostellate, costellae narrow, elevated, about equal in width to the spaces between them; about 8 costellae in 5 mm. at the front margin of a specimen 21 mm. long; costellae produced in several generations; costellae crossed by strong elevated fila.

Pedicle valve unevenly convex in lateral profile, most convex in posterior half but convexity very low; anterior half gently convex; anterior profile broadly but slightly convex; umbo narrowly convex, the convexity continued anteriorly as a low fold perceptible in most specimens to the front margin, in a few fairly conspicuous; flanks bounding sulcus depressed convex; posterolateral extremities deflected more or less strongly toward the brachial valve. Interarea moderately long, strongly apsacline. Interior with short dental plates and shallow umbonal

cavities; muscle area somewhat quadrate, gently indented anteriorly and extending about one-third the length; pallial impressions not strongly marked.

Brachial valve gently convex in lateral profile; broadly convex in anterior profile and with the median region more or less strongly indented. Umbo sulcate; sulcus narrow and shallow to moderately deep in the posterior half, widening and shallowing, often to disappearance anteriorly; flanks bounding sulcus somewhat narrowly rounded and with short but fairly steep lateral and posterolateral slopes. Interior with short, low median ridge, short brachiophores, and stout but short cardinal process; lateral processes occasionally developed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|--------|-------------|-----------|
| Holotype | 21.7 | 21.5 | 26.0 | 22.0 ? | 8.5 |
| Paratype (110425a) | 25.5 | 24.8 | 31.2 ? | ? | 9.8 |
| " (110425e) | 21.7 | 21.5 | 27.3 ? | 23.4 ? | 8.2 |
| " (110425i) | 21.1 | 20.8 | 28.7 ? | 27.2 ? | 8.1 |
| " (110425j) | 18.6 | 18.3 | 23.3 | 20.8 | 7.0 |

Types.—Holotype: 110414b,c (these are etched valves of one individual); figured paratypes: 110414a, 110425b,e; unfigured paratypes: 110425a,c,d,f-i, measured paratype 110425j.

Horizon and locality.—Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species is represented by numerous specimens, but not one of them is perfect enough to permit the making of really good measurements. The species is characterized by its large size, generally strong fold and fairly deep and wide sulcus, although both features are variable. It differs from *M. quadrata* in the stronger fold and sulcus.

MULTICOSTELLA QUADRATA Cooper, new species

Plate 63, C, figures 13-21

Shell large for the genus, slightly wider than long; hinge forming the widest part; sides nearly straight; anterolateral extremities rounded; anterior margin truncated to gently rounded; cardinal extremities slightly auriculate; anterior commissure rectimarginate; lateral commissure very slightly deflected in the direction of the brachial valve in the posterolateral region; surface multicostellate, costellae rounded and swollen, closely crowded with striae narrower than the costellae; costellae numbering 12 in 5 mm. at the anterior margin.

Pedicle valve unevenly convex with the most convex part in the posterior half and with the anterior half flattened; anterior profile forming a broad triangle with the median region narrowly rounded and the flanks sloping by a low descent to the margins; umbo narrowly plicate to subcarinate, the carina continued to the middle as a well-defined fold but becoming indistinct or obsolete anterior to the middle; flanks slightly swollen and descending by a very gentle slope to the margins; posterolateral area small, flattened; interarea moderately long, moderately apsacline. Interior with small teeth; dental plates obsolete; muscle area

longitudinally rectangular, anterior gently indented medianly; muscle field extending nearly to middle; diductor scars large; adjustor scars prominent. Pallial impressions not strong.

Brachial valve moderately and fairly evenly convex; anterior profile broadly convex and only slightly indented medianly; umbo somewhat swollen, sulcate; sulcus narrow, moderately deep, extending to the middle; anterior half swollen to obliterate sulcus or to make it indistinct. Flanks bounding sulcus moderately swollen; posterolateral slopes short, gentle; posterolateral extremities short and flattened. Interior with fairly prominent median ridge occupying the posterior third; notothyrial platform thickened; cardinal process slender; brachiphores short and stout.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 19.6 | 19.0 | 23.0 | 23.3 | 8.0 |
| " (116989c) | 22.6+ | 22.3 | 26.2 | ? | 7.8 |
| " (98189d) | 18.9 | 18.4 | 21.2 | 21.9 | 6.5 |
| " (98189a) | 15.5 | 15.8 | 18.2 | 17.9 ? | 6.2 |
| " (98189b) | 25.5 | 25.9 ? | 31.8 | ? | 8.7 |

Types.—Holotype: 116989a; figured paratypes: 98189a,c,g; unfigured paratypes: 98189b,d-f, 116989b-e.

Horizon and locality.—Whistle Creek formation in Virginia: On U. S. Highway 60, 100 yards southeast of Whistle Creek, 2 miles northwest of Lexington, Lexington (15') Quadrangle; road along Purgatory Creek, $\frac{1}{2}$ mile southwest of the Dunkard Church, 6 miles north of Buchanan, Natural Bridge (15') Quadrangle.

Ellett formation in Virginia: Ellett and Lusters Gate, Blacksburg (15') Quadrangle.

Discussion.—This species is characterized by its subquadrate form and nearly straight sides. It suggests *M. plicata* of the Lincolnshire formation but differs in not possessing the strong fold and sulcus of that species.

MULTICOSTELLA RECTANGULATA Cooper, new species

Plate 61, B, figures 7-10; plate 64, B, figures 6-9

Shell of about medium size for the genus, transversely rectangular in outline; sides gently rounded; anterior margin broadly rounded to slightly emarginate; anterior commissure rectimarginate; surface multicostellate, costellae crowded and with striae narrower than the costellae which number about 12 to 13 in 5 mm. at the anterior margin.

Pedicle valve unevenly convex in lateral profile with the posterior half slightly convex and the anterior half flattened; anterior profile broadly triangular, the median part narrowly convex but low and with long, gently sloping sides; umbo swollen narrowly, the swelling produced anteriorly to form a low but poorly defined narrow fold extending to a point anterior to the middle; flanks flattened and slightly depressed below the median elevation; posterolateral extremities flattened and deflected toward the brachial valve. Interarea long, apsacline.

Brachial valve gently convex, most convex in the posterior half but flattened anteriorly; anterior profile broadly but gently convex; umbo sulcate, sulcus narrow and shallow to the middle, somewhat indistinctly defined in the anterior half; flanks moderately convex; slopes to posterolateral extremities short and fairly steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|--------|-------------|-----------|
| Holotype | 22.4 | 22.3 | 30.4 | ? | 8.7 |
| Paratype (116990) | 19.7 | 20.6 | 26.6 ? | 25.8 ? | 7.0 |
| " (123456) | 11.4 | 11.3 | 15.5 | 15.7 | 4.3 |

Types.—Holotype: 116991; figured paratypes: 116990, 123456.

Horizon and locality.—Yellow limestone above 25-foot sandstone at base of Eureka group in Roberts Mountains (1°) Quadrangle, Nevada: Saddle just north of hill 8167, Martins Ridge, Monitor Range; 2 miles north of Martin Ranch.

Discussion.—This species is characterized by its considerable width. In this respect it differs strongly from *M. parallela* which occurs in the same region. It is likewise wider than any of the described eastern species.

MULTICOSTELLA ROBUSTA Cooper, new species

Plate 63, B, figures 8-12

Shell small for the genus, wider than long with the hinge about equal to the width at the middle; cardinal extremities approximately a right angle; valves fairly strongly and subequally deep; sides nearly straight; anterior margin broadly rounded; anterior commissure rectimarginate; lateral commissure slightly deflected toward the brachial valve in its posterior part; multicostellate; costellae closely crowded, unequal in size, about 13 in 5 mm. at the front margin.

Pedicle valve very gently convex in lateral profile; anterior broadly convex with the greatest height in the middle but with long gentle lateral slopes; umbonal and median regions moderately swollen; fold only defined at the umbo; lateral areas flat but gently swollen and with very gentle slopes to the margins.

Brachial valve unevenly and fairly strongly convex in lateral profile; posterior half gently convex; anterior half somewhat abruptly flattened; umbo swollen; umbo sulcate, sulcus scarcely defined anterior to the middle. Median region and flanks inflated; slopes to posterolateral areas short and steep; posterolateral regions small.

Measurements in mm.—Holotype, length 17.3, brachial length 17.2, width 20.6, hinge width 17.6, thickness 7.3.

Types.—Holotype: 116992a; unfigured paratypes: 116992b,c.

Horizon and locality.—Lower part of the Sevier formation in Tennessee: ¼ mile north of Gooseneck, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This species is characterized by its fairly small size, rectangular form, crowded costellae, and thick cross section. It is somewhat suggestive of

M. semisulcata but differs in details of the costellae, more robust cross section, and more quadrate form.

MULTICOSTELLA SAFFORDI (Hall and Clarke)

Orthis ? saffordi HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 218, 340, pl. 5A, figs. 38-40, 1892.

Multicostella saffordi (Hall and Clarke) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 98, 1932.

Although many specimens of *Multicostella* from eastern Tennessee appear in the National Collection and that of the Geological Survey, it has proved impossible to identify any of them with Hall and Clarke's description of *O. ? saffordi*. Inasmuch as their specimen could have come from any one of numerous horizons and their description is so brief and noninformative, it is at present impossible to identify the specimen except to be sure that it is a *Multicostella*. The specimen is said to have come from Knoxville, Tenn. This probably means that it could have been derived from an area of several miles radius from Knoxville, an area that includes beds from the Lenoir to the Sevier, but derivation from the Arline formation seems probable.

Type.—Holotype: N. Y. State Mus. 7932/1.

MULTICOSTELLA SEMISULCATA Cooper, new species

Plate 64, D, figures 17-26; plate 71, G, figures 36-40

Multicostella saffordi SCHUCHERT and COOPER, (not Hall and Clarke), Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 98, pl. 8, figs. 23, 27, 1932.

Shell large for the genus, wider than long; hinge as wide or wider than the width at the middle; valves subequally convex with the brachial valve slightly the deeper; sides rounded; anterior margin broadly rounded; anterior margin rectimarginate to broadly uniplicate; lateral commissure deflected toward the brachial valve in the posterior part; surface multicostellate; costellae and striae about equal in width, costellae numbering about 8 in 5 mm. at the front of a large adult.

Pedicle valve with unevenly convex lateral profile, the posterior half having a greater convexity than the anterior half which is flattened; anterior profile broadly triangular with the median area narrowly humped-up and with flat but moderately steep slopes to the margins. Umbonal and posteromedian region swollen and forming a broad fold; anterior half somewhat flattened; posterolateral slopes long and gentle; interarea moderately long, apsacline; interior with muscle field occupying posterior third.

Brachial valve moderately convex in lateral profile, broadly convex in anterior profile; umbo gently swollen, sulcate; sulcus prominent but shallow in the posterior half, not defined on the anterior half; median and anteromedian areas somewhat swollen; slopes to margins gentle; interior with strongly thickened notothyrial platform, stout cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.2 | 13.5 | 17.5 | 15.7 | 5.2 |
| Paratype (110433) | 22.2 | 22.4 | 28.3 | 22.6 | 8.8 |

Types.—Holotype: 110474b; figured paratypes: 110433, 110474a,c,e; unfigured paratype: 110474d.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: In Evans Ferry section about 1 mile north of Indian Creek on U. S. Highway 25E, Howard Quarter (T.V.A. 162-NW) Quadrangle; 0.4 mile east-northeast of Red Hill, Avondale (T.V.A. 162-SW) Quadrangle; 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 3 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; Maynardville Pike, 1.7 miles north-northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; Raccoon Valley, 1 mile north of Wilson, Briceville (30') Quadrangle.

Lincolnshire formation in Virginia: At Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is similar to *M. plicata* from the closely related Lincolnshire formation but does not have the strong fold and sulcus so characteristic of the Lincolnshire form. The shape and costellae help to separate *M. semi-sulcata* and *M. quadrata*. Furthermore, the pedicle muscle field of *M. quadrata* is much smaller than that of the other two species.

MULTICOSTELLA SULCATA Cooper, new species

Plate 71, A, figures 1-4

Shell of moderate size for the genus; wider than long with rectangular cardinal extremities; sides nearly straight; anterior margin broadly rounded; anterior commissure nearly rectimarginate despite a narrow fold and sulcus; costellate, costellae numbering 7 or 8 in 5 mm. at the front margin. Costellae with tendency toward fasciculation.

Pedicle valve very gently convex in lateral profile; anterior profile very gently convex but with a narrow median hump; umbonal region slightly swollen; median fold strong, subcarinate, narrow, extending from beak to anterior margin. Flanks bounding fold depressed to gently concave; interarea moderately long, nearly catacline.

Brachial valve gently convex and of about the same depth as the pedicle valve in lateral profile; anterior profile moderately convex with a deep and narrow median groove; sulcus strong, deep, narrow, extending from umbo to anterior margin. Flanks bounding sulcus forming narrow, strong plications; lateral slopes short and steep. Interarea short, anacline.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.1 | 17.1 | 20.5+ | ? | 6.7 |
| Paratype (pedicle valve) | 16.9 | ? | 20.7 | 20.7 | ? |

Types.—Holotype: 116993; figured paratype: 110459.

Horizon and locality.—Bromide formation (Mountain Lake member—*Valcourea transversa* bed) in Oklahoma: In NE $\frac{1}{4}$ sec. 1, T. 2 S., R. 2 W., 3 miles east of Pooleville; on Spring Creek in sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species differs from all other described forms in the strength of the pedicle fold and the deep brachial sulcus.

Genus CAMPYLORTHIS Ulrich and Cooper, 1942

Campylorthis ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 621, 1942.

Shells wider than long, cardinal extremities varying from alate to obtusely rounded. Lateral profile convexi-concave to unequally biconvex, the brachial valve always the deeper. Anterior commissure varying from rectimarginate to uniplicate. Interareas subequal in length, pedicle one generally apsacline; brachial interarea orthocline to anacline and usually extended posterior to the pedicle beak. Surface multicostellate, costellae of unequal size; impunctate.

Pedicle valve with musculature of *Dinorthis* consisting of elongate, anteriorly widening, and divergent diductor scars, moderately strong adjustor impressions at the base of the dental plates, and small adductor field bisected by a low median ridge. Muscle area square to elongate rectangular in outline. Teeth small but with large fossettes; dental plates short, stout, and receding, defining small umbonal cavities. Pallial markings as in *Dinorthis*. Delthyrium covered.

Brachial cardinalia as in Dinorthisidae; brachiophores short, rodlike, supported by excess shell deposited on their inner surface. Cardinal process with short shaft and narrow crenulate myophore in the young but with swollen and triangular myophore in old specimens. Median ridge short, adductor field small.

Genotype.—*Strophomena deflecta* Conrad = *Campylorthis deflecta* (Conrad), Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 332, 1843.

Discussion.—*Campylorthis* most nearly resembles *Multicostella* and possesses a similar pedicle muscle arrangement and pallial marks but differs in profile. *Multicostella* is biconvex in lateral profile, but *Campylorthis* has the pedicle valve concave in the anterior half or two-thirds. In some individuals this concavity is not strongly marked and differentiation from *Multicostella* is difficult.

The type species of *Campylorthis* was long ago assigned to the genus *Valcourea*, and the common presence of a pseudodeltidium in the two genera made this similarity striking. Nevertheless, an important difference in the cardinal process of the two may be noted. That of *Valcourea* possesses a high median ridge rising above the myophore, but the cardinal process of *Campylorthis* is marked by no such ridge and the structure is like that of *Dinorthis* with a crenulate myophore.

Campylorthis is also similar to *Chaulistomella* and differs from it only in the possession of a pseudodeltidium. When *Campylorthis* was first proposed, the name included the shells now referred to *Chaulistomella*. It seemed advisable to separate the two, however, because true *Campylorthis* with the pseudodeltidium seems to be confined to the Mississippi Valley region. *Chaulistomella*, some

species of which are close homeomorphs of *Campylorthis*, abounds in the Appalachians.

Chaulistomella is a variable genus in its exterior form, some of the species having the deeply concave pedicle valve similar to that of *Campylorthis*, but others are more like *Multicostella* in exterior form. As far as known, none of them has been found with a pseudodeltidium in place.

CAMPYLORTHIS DEFLECTA (Conrad)

Plate 69, A, figures 1-6

Strophomena deflecta CONRAD, Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 332, 1843.

S. recta CONRAD, *ibid.*, p. 332.

Plaesiomys loricula HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 197, 341, pl. 5A, figs. 31-34, 1892.

For complete bibliography, see Bassler, U. S. Nat. Mus. Bull. 92, p. 442, 1915.

Valcourea deflecta (Conrad) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 97, 1932.

Shell fairly large, subelliptical in outline; hinge generally narrower than the shell width at the middle; cardinal extremities acute in the young, obtusely rounded in the adult; sides gently rounded; anterior margin broadly rounded; anterior commissure strongly uniplicate; lateral margin strongly deflected toward the brachial valve; surface costellate, costellae broadly rounded and separated by striae narrower than the costellae; about 10 costellae in 5 mm. at the front margin of a large adult.

Pedicle valve unevenly concave in lateral profile, with the umbonal region gently convex but the anterior two-thirds fairly deeply concave; anterior profile broadly concave; umbo narrowly convex, the convexity extended anteriorly to about the middle as a low fold; valve deeply sulcate anterior to the middle; flanks deflected toward the pedicle valve and therefore concave; cardinal extremities prominently deflected toward the brachial valve; interarea strongly apsacline to catacline; delthyrium covered by a large convex pseudodeltidium. Interior with small teeth having deep fossettes; muscle field squarish in outline with prominent adjustor scars at the base of the dental plates; diductor scars prominent; pallial impressions not strongly marked.

Brachial valve unevenly convex in lateral profile, the umbo flattened, the median region moderately convex and the front somewhat flattened; anterior profile strongly convex with the greatest convexity in the median region and with steep and abrupt lateral slopes. Umbo flattened but sulcate; sulcus narrow, shallow, extending to the middle where it disappears into a more or less prominent fold of the anterior half; median and anterior regions forming a broad fold with the flanks sloping strongly to the margins. Posterolateral areas concave with outer side deflected toward the brachial direction. Interarea long and flat, orthocline with a prominent chilidium. Notothyrial platform strongly thickened; median ridge occupying the posterior third; brachiophores stout; cardinal process moderately long and thick; pallial marks not deeply impressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (36101a)..... | 18.4 | 19.4 | 25.2 | 22.5 | 6.3 |
| " (36101b)..... | 14.7 | 16.2 | 22.1 | 19.3 | 5.5 |
| " (36101c)..... | 12.3 | 12.8 | 17.0 | 18.0 | 4.4 |

Figured hypotype.—36101a; measured hypotypes: 36101b,c.

Horizon and locality.—Platteville formation (McGregor member) in Wisconsin: At Highland, Iowa County; Mineral Point, Iowa County; Beloit, Rock County; quarry on Wisconsin Highway 81, 1 mile northwest of Ellenboro, Lancaster (30') Quadrangle; Rocktown; Gratiot, Lafayette County; Janesville, Rock County; Pomeroy Quarry, River Falls, Pierce County; Dodgeville, Iowa County; Argyle, Lafayette County; NE $\frac{1}{4}$ sec. 8, T. 3 N., R. 1 W., Platteville Township, Grant County; 0.1 mile south of the Little Platte River on Wisconsin Highway 81, 2 miles northwest of Platteville, Lancaster (30') Quadrangle.

Same formation in Minnesota: At Minneapolis.

Same formation in Illinois: At Dixon, 1.5 miles northeast of Dixon; Lee County; 3 miles above Savanna, Jo Daviess County.

Discussion.—This species has the appearance of a large and robust *Valcourea*. In the young the cardinal extremities are angular and often auriculate. It is probably to some young specimens that Conrad gave the name *Strophomena recta* in 1843. Hall's figures in Paleontology of New York, vol. 1, suggest a young form.

Some variation is apparent in the concavity of the pedicle valve. A few specimens show a nearly plane pedicle valve, but the majority of them indicate a strongly concave pedicle valve and a folded, uniplicate brachial valve. These features distinguish *C. deflecta* from *C. subplana*.

CAMPYLORTHIS SUBPLANA Ulrich and Cooper, new species

Plate 68, B, figures 5-12

Campylorthis deflecta ULRICH and COOPER (not Conrad), Journ. Paleont., vol. 16, No. 5, pp. 621, 622, 1942.

Shell of about usual size for the genus, wider than long; subelliptical to subrectangular in outline; hinge narrower than the width at the middle in adults but forming the widest part in young specimens; cardinal extremities alate in the young but narrowly rounded in adults; anterior commissure gently uniplicate; lateral commissure strongly deflected in the brachial direction at the cardinal extremities; surface multicostellate; costellae broad and with striae narrower than the costellae; about 10 to 12 costellae in 5 mm. at the front margin.

Pedicle valve unevenly convex in lateral profile, the umbonal region slightly convex but the remainder gently concave, anterior profile broadly and gently concave; umbonal region narrowly convex, the convexity continued to the middle as a low fold; anteromedian area depressed into a shallow sulcus; flanks gently concave; cardinal extremities strongly and abruptly deflected toward the brachial valve; interarea long, nearly catacline; muscle field rectangular in out-

line, large; adjustor impressions moderately developed; diductor scars large; dental plates short.

Brachial valve strongly convex in lateral profile with the maximum convexity in the median region; anterior profile strongly convex and with steep slopes to the margins; umbonal region flattened, sulcate, sulcus short, shallow, narrow, extending to the middle; median region, anterior, and flanks all swollen and with steep lateral and anterior slopes. Notothyrial platform thickened; cardinal process slender; median ridge short.

Measurements in mm.—Holotype, length 20.2, brachial length 21.6, width 24.7, hinge width 22.1, thickness 9.0.

Types.—Holotype: 108199a; figured paratypes: 108199b-d.

Horizon and locality.—Plattin group (Macy formation) or Barnhart formation in Missouri: On old road 1 mile northwest of Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E.; on Fredericktown road 5 miles southwest of Ste. Genevieve, Weingarten (15') Quadrangle; Rockwood's Reservation, 20 miles west of St. Louis on Manchester Road, 1 mile west of Grover, St. Louis County.

Discussion.—This species is similar to *C. deflecta* (Conrad) in outline and ornamentation but differs in having a much less concave pedicle valve, a less strongly folded brachial valve, and much more strongly deflected cardinal extremities. The Plattin form is, furthermore, a much more robust shell with greater depth and more strongly convex brachial valve.

CHAULISTOMELLA Cooper, new genus

Greek *chauli*, gaping; *stoma*, mouth)

This name is proposed for shells morphologically intermediate between *Multicostella* and *Campylorthis*. It is possible that the latter genus is more closely related to *Valcourea*, but some of the species of *Chaulistomella* closely resemble *Valcourea* and *Campylorthis*. Externally *Chaulistomella* is unlike *Multicostella* in having the anterior half of the pedicle valve deeply depressed or concave. In young forms or in a few species the resemblance to *Multicostella* is very strong and the genera are difficult to separate. Inside the pedicle valve the musculature is exactly like that of *Multicostella*, *Campylorthis*, and the rest of the Dinorthisidae.

The brachial valve of *Chaulistomella* is always strongly convex, but the cardinal process is not provided with a high median crest such as that of *Valcourea*. In this respect it is like *Campylorthis* but differs from that genus in not having a strong pseudodeltidium. The distinction between *Multicostella* and *Chaulistomella* is thus based on the concave pedicle valve; the distinction between *Chaulistomella* and *Campylorthis* is based on the absence of a pseudodeltidium in the former genus. Not only is the pseudodeltidium absent from *Chaulistomella*, but no trace of it has been seen in any young specimens examined.

Genotype.—*Chaulistomella inequistriata* Cooper, new species.

CHAULISTOMELLA BREVIS (Willard)

Plate 65, B, figures 7-12; plate 66, B, C, figures 10-27

Plaesiomys brevis WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 268, pl. 1, figs. 12, 14, 1928.*P. platys* WILLARD (not Billings), idem, p. 266, pl. 1, figs. 10, 11, 1928.

Shell subrectangular in outline, wider than long, hinge nearly a right angle or extended slightly to have a width greater than that at the middle; cardinal extremities often forming small ears; sides nearly straight or gently rounded; anterior margin broadly rounded; anterior commissure rectimarginate to slightly and broadly uniplicate. Surface multicostellate, costellae not strongly differentiated, 10 to 14 in the space of 5 mm. at the front margin. Concentric fila strongly developed, about 4 or 5 to the millimeter at the middle.

Pedicle valve unevenly convex in lateral profile, the posterior half very gently convex but the anterior half gently concave. Umbonal region gently swollen, somewhat narrowly swollen medianly with the swelling extended anteriorly as a more or less well developed narrow fold. Anteromedian region flattened or gently concave; lateral extremities deflected moderately in the direction of the brachial valve. Interarea moderately long, strongly apsacline. Interior with small, moderately indented muscle field; pallial trunks not strongly developed.

Brachial valve moderately convex in lateral profile with the greatest convexity in the posterior two-thirds; anterior third somewhat flattened. Anterior profile broadly and moderately convex; median region swollen; umbo gently sulcate, sulcus disappearing before the middle; anterior and lateral slopes moderately steep, fairly short. Interarea gently apsacline. Interior with short, thick median ridge, thick notothyrial platform, and stout cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (116995a)..... | 25.1 | 26.1 | 31.2 | 30.5 | 8.2 |
| " (116994e)..... | 20.4 | 21.0 | 25.2 | 22.8 | 6.8 |
| " (110462b)..... | 17.4 | 18.0 | 21.0 | 20.7 | 6.0 |

Types.—Holotype: M.C.Z. 8600c; figured hypotypes: 110462b,d, 116994a-e, 116995a.

Figured specimen.—*Plaesiomys platys* Willard (not Billings): M.C.Z. 8598.

Horizon and locality.—Benbolt formation and Benbolt part of Dryden formation in Tennessee: $1\frac{1}{4}$ miles west of Lone Mountain; $1\frac{1}{2}$ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; roadside $1\frac{1}{2}$ miles northeast of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle; Liberty Hill north of Lutrell, Dutch Valley (T.V.A. 154-SE) Quadrangle; hillside south of Dutch; $\frac{1}{2}$ mile southwest of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle.

Benbolt formation in Virginia: At Fugates Hill north of Mendota, Bristol (30') Quadrangle; south side of Mount Hagan School, southeast corner of the northeast subquad., Hilton (T.V.A. 197-NW) Quadrangle; 100 feet above

Echinosphaerites, on Virginia Highway 74, $5\frac{1}{2}$ miles east of its junction with U. S. Highway 54 (Virginia 71); on Virginia Highway 71, 0.2 mile southwest of Bethel Church, $\frac{1}{2}$ mile east of the junction with U. S. Highway 54, Hilton (T.V.A. 197-NW) Quadrangle; $\frac{1}{2}$ mile northeast of Speers Ferry; $1\frac{1}{2}$ miles southwest of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; 1.2 miles south of the middle fork of Moccasin Creek, $\frac{1}{2}$ mile south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; 0.67 mile south of Tumbes, Moll Creek (T.V.A. 196-SE) Quadrangle; north side of U. S. Highway 19, $1\frac{3}{4}$ miles southeast of Hansonville Post Office, Brumley (T.V.A. 205-SE) Quadrangle.

Low in the Sevier formation in Tennessee: $\frac{1}{4}$ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This species is characterized by its very large size, its nearly flat pedicle valve, and brachial valve of low convexity. The species was based by Willard on two specimens which are immature forms. Furthermore, the specimen assigned by Willard to Billings' species *Multicostella platys* is actually a very fine large example of his *C. brevis*. This species is common in the Benholt formation in its shaly facies in southwestern Virginia and adjacent northern Tennessee.

The species is similar to *C. inaequistriata*, but the largest specimens are larger than the largest of *C. inaequistriata*. It also differs from that species in having more even-sized costellae, a less strongly developed fold, and less alate cardinal extremities.

CHAULISTOMELLA CRASSA Cooper, new species

Plate 71, B, figures 5-9a

Shell of about medium size for the genus, wider than long with the hinge slightly wider than the midwidth; cardinal extremities subalate; sides sloping medianly more or less strongly; anterior margin broadly rounded; anterior commissure broadly uniplicate; surface multicostellate, costellae unequal in size, strong and wide but separated by spaces slightly narrower than the costellae; about 6 costellae in 5 mm. at the anterior margin.

Pedicle valve with uneven lateral profile, the umbonal region moderately convex but the anterior two-thirds flattened to moderately concave; anterior profile very gently convex; umbonal region slightly swollen but without distinctly marked narrow fold; median region moderately concave; flanks bounding concavity moderately swollen into a broad plication separating the concave median region from the cardinal extremities which are deflected toward the brachial valve. Interarea long and strongly apsacline. Muscle field of moderate size.

Brachial valve with uneven lateral profile, the posterior half fairly strongly convex but the anterior half flattened. Median region swollen; umbo gently swollen, slightly sulcate; sulcus indistinct or obsolete anterior to the middle; lateral slopes long and gentle; anterior slope long and gentle; umbonal slope steeper than the lateral slopes but fairly gentle. Interarea long and orthocline to gently apsacline.

Measurements in mm.—Holotype, length 15.8, brachial length 16.2, width 21.0, hinge width 22.2, thickness 6.0.

Types.—Holotype: 116996a; figured paratype: 116996b.

Horizon and locality.—Bromide formation (Mountain Lake member—just above bryozoan bed=*Mimella* zone) in Oklahoma: On Oklahoma Highway 99, 3 miles south of Fittstown, Pontotoc County.

Discussion.—This is apparently a rare fossil because only two specimens have been found in all the years of collecting in Oklahoma. It is chiefly characterized by the coarse costellae which are stronger than those of any other species of this genus for a shell of medium size. In form the species suggests *C. superlata* from Georgia but differs in its stronger costellae and the distinct but broad uniplicate anterior commissure.

CHAULISTOMELLA ELONGATA (Willard)

Plate 65, D, figures 18-20

Plaesiomys elongata WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 267, pl. 1, figs. 15, 16, 1928.

This is a rare species, and only a few specimens in all the collections of the National Museum and the Geological Survey are referred to it. The figured specimen has a somewhat more concave pedicle valve and a less convex brachial valve than the type specimen, but the outline and ornamentation agree fairly well.

Types.—Figured hypotypes: 110473a,b.

Horizon and locality.—Benbolt part of Dryden formation in Tennessee: At Liberty Hill, north of Luttrell, Dutch Valley (T.V.A. 154-SE) Quadrangle; 100 yards west of the store at the juncture of Tennessee Highway 33 and the Flint Creek road, Maynardville (T.V.A. 145-SE) Quadrangle.

CHAULISTOMELLA INAEQUISTRIATA Cooper, new species

Plate 65, A, figures 1-6; plate 68, C, figures 13-20; plate 69, C, figures 17-21;
plate 69, D, figure 22; plate 72, B, figures 6-13

Multicostella cf. *M. platys* (Billings) BUTTS, Virginia Geol. Surv. Bull. 52, pl. 90, figs. 37-48, 1942.

Shell of about usual size for the genus; wider than long; widest part at hinge, but in some the hinge is narrower than the midwidth; cardinal extremities generally acutely angular, often subulate, occasionally obtuse. Lateral margins concave just anterior to the cardinal extremities but nearly straight to sloping medially anterior to the middle, but occasionally broadly rounded. Anterior margin nearly straight to gently rounded. Anterior commissure varying from faintly unisulcate to slightly uniplicate but generally rectimarginate. Lateral profile varying from convexi-concave to convexiplane in the adults and generally unequally biconvex in the young forms. Surface multicostellate, costellae appearing by implantation in 5 generations, and varying between 9 to 15 in 5 mm. at the front. A few specimens show strong fasciculation of the costellae about the ribs of the first generation.

Pedicle valve in lateral profile gently convex in posterior half but gently to moderately concave in the anterior half. Beak inconspicuous, umbo slightly swollen; fold variable extending anteriorly from beak to front margin or disappearing in the anterior half. Fold generally marked by a median costella stronger than surrounding ones. Region in front of cardinal extremities gently concave; flanks of shell separating concave median area from cardinal extremities generally gently convex. Interarea strongly apsacline to nearly procline, about equal in length to the interarea of the brachial valve. Delthyrium open.

Brachial valve moderately convex in lateral profile; moderately convex in anterior profile with center sulcate. Sulcus originating and generally extending as a shallow and narrow depression anteriorly to the front margin but disappearing posterior to the front margin in some specimens. Flanks bounding sulcus gently swollen with long gentle concave slope to cardinal extremities and with moderate slopes to the anterior margin. Interarea long, orthocline to apsacline and extending posterior to the pedicle beak.

Pedicle interior with muscle field about as long as wide, not deeply impressed; pallial marks not well developed. Brachial interior with short median ridge; ponderous cardinal process and strong development of excess shell about the cardinal process and brachiophores.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 21.2 | 22.7 | 26.6 | 29.4 | 8.8 |
| Paratype (110484a) | 20.3 | 21.0 | 25.0 | 28.4 | 8.1 |
| “ (110484i) | 6.2 | 6.6 | 7.3 | 7.5 | 2.0 |
| “ (110484g) | 8.1 | 8.3 | 11.4 | 12.4 | 3.1 |
| “ (110484c) | 17.7 | 18.5 | 22.0 | 28.4 | 6.4 |
| “ (110484b) | 23.0 | 24.5 | 29.7 | 32.4 | 9.2 |
| “ (110519a) | 18.0 | 18.9 | 22.4 | 20.7 | 7.6 |
| “ (110519f) | 21.0 | 22.5 | 24.4 | 22.2 | 7.5 |

Types.—Holotype: 98212a; figured paratypes: 98212f,g, 110484b, 110488a,b, 110519a,f, 116997b, 116998a; unfigured paratypes: 98212b-e, 110484a,c-i, 110519b-e,g-t, 116997a,c,d.

Horizon and locality.—Wardell formation (shaly facies) in Tennessee: 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; $\frac{1}{2}$ mile west of Dodson Creek on the road from Acuff to Tennessee Highway 33, Maynardville (T.V.A. 145-SE) Quadrangle; valley west of Copper Ridge on Rogersville-Sneedville road, Lee Valley (T.V.A. 171-NW) Quadrangle; 4 miles northwest of Rogersville, Pressmens Home (T.V.A. 171-NE) Quadrangle; Davis store west of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Dryden formation on Tazewell (T.V.A. 154-NE) Quadrangle in Tennessee: Lone Mountain to Tazewell road, $1\frac{1}{2}$ miles northeast of Lone Mountain; road along Little Sycamore Creek, 0.35 mile northeast of Halls School.

Same horizon on Clinchport (T.V.A. 188-NW) Quadrangle in Virginia: At Mannville School; 20 feet below top on U. S. Highway 58, $\frac{1}{4}$ mile west of Danl-

boone Yard on road from Gate City to Speers Ferry; Lloyd Carter's barn, 0.8 mile northeast of school at Rye Cove; near new school at Rye Cove.

Discussion.—This species is characterized by its unequal costellae, generally well developed alate cardinal extremities, strong fold and sulcus for the genus, and the generally compressed form. No other species has this combination of characters. *Chaulistomella superlata* has some resemblance, but it is generally a proportionally wider species and has a more concave pedicle valve. None of the Oklahoma species is very similar because they have much more convex brachial valves and are generally not so strongly alate.

This species is quite variable particularly in the hinge region. Some specimens are fairly quadrate in outline and have nearly rectangular or obtuse cardinal extremities. They are apparently extremes, prevented from developing their normal alate form by overcrowded living conditions.

CHAULISTOMELLA LEBANONENSIS Cooper, new species

Plate 65, E, figures 21-30; plate 69, E, figure 23

Shell of about the usual size for the genus, about one-third wider than long. Cardinal extremities approximately a right angle, usually strongly rounded. Sides nearly straight or moderately strongly rounded; anterior margin gently rounded to subtruncate. Anterior commissure broadly uniplicate. Surface multicostellate, 10 to 12 costellae occupying a space of 5 mm. at the front margin of an adult. Costellae narrowly rounded and separated by furrows narrower than the costellae.

Pedicle valve gently convex in the umbonal region but flatly convex anteriorly; fold varying from scarcely visible to fairly strong and extending from beak to anterior margin. Anterolateral regions flattened. Interior with large quadrate muscle area having large adjustor scars and large diductor impressions. Pallial impressions not strong.

Brachial valve fairly strongly convex in lateral profile with the most convex part in the posterior half; anterior profile strongly convex with steep, flattened to slightly concave sides. Sulcus well defined to nearly obsolete. Posterolateral slopes steep; cardinal extremities deflected. Interarea shorter than the pedicle one, apsacline, not extended posterior to the posterior margin of the pedicle valve.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.9 | 18.0 | 23.6 | 19.6 | 9.2 |
| Paratype (pedicle valve 110533a).... | 18.9 | ? | 24.9 | 22.5 | ? |
| " (27286a) | 17.0 | 17.3 | 21.8 | ? | 6.0 |

Types.—Holotype: 84024a; figured paratypes: 110523a, 110524a, 110533a, 110534a; unfigured paratypes: 27286a, 84024b, 110523b, 110524b, 110533b-e, 110534.

Horizon and locality.—Lebanon formation in Tennessee: At Lebanon, Wilson County; Columbia, Maury County: 3 miles east of Murfreesboro, Rutherford County; cut on U. S. Highway 41, $\frac{3}{4}$ mile south of Knox Branch, 9 miles south-

east of Murfreesboro, Rutherford County; Rutherford Creek, 4 miles north of Columbia, Maury County; near Clifton, Wayne County.

Carters formation in Alabama: At a quarry $\frac{1}{2}$ mile north of Gate City, Leeds (15') Quadrangle.

Camp Nelson formation in Kentucky: At High Bridge, Harrodsburg (30') Quadrangle.

Discussion.—This species has a very strong resemblance to *Campylorthis*, but not one of the numerous specimens in the collection has shown any trace of a pseudodeltidium. The generally small size, fairly deeply concave pedicle valve, and strongly convex brachial valve will help to place it. It resembles *C. superlata* from Georgia, but that is a larger and more coarsely costellate species. It also resembles *C. rectangulata* from the Wardell formation in the Evans Ferry section but differs in having a more concave pedicle valve and less swollen brachial valve.

CHAULISTOMELLA MAGNA (Schuchert and Cooper)

Plate 70, B, figures 11-23

Dinorthis subquadrata DECKER (not Hall), Oklahoma Geol. Surv. Bull. 55, pp. 42, 46, pl. 13, fig. G, 1931.

Valcourea magna SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 98, pl. 10, figs. 16, 20, 27-29, 1932.

A large and robust species characterized by its size and beautiful ornamentation. Shell subquadrate in form and having the valves unequally convex, the pedicle valve very gently convex while the brachial valve is moderately convex. Fold low and poorly defined, from the beak to the front margin, but, as usual in dinorthis, best defined on the posterior half. Flanks of shell bounding the fold flattened or gently depressed.

Brachial valve much deeper than the pedicle valve and moderately convex in lateral profile. Sulcus very shallow over its whole length but best defined at the posterior half. Flanks bounding sulcus gently swollen. Interareas nearly of the same length, the brachial one, however, slightly the shorter. Surface multicostellate, the costellae low and rounded, with unequal interspaces. Scattered primary costellae often swollen and enlarged.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (110539c)..... | 26.8 | 27.2 | 34.6 | 33.0 | 13.0 |
| " (110545)..... | 25.8 | 26.0 | 34.0 | 31.9 | 12.3 |

Types.—Holotype: Y.P.M. (Schuchert coll.) 5779; figured hypotypes: 110539c, 110543a, 110545, 116999b; unfigured hypotypes: 110539a,b, 110543b-d, 116999a.

Horizon and locality.—Bromide formation (Pooleville member—*Oxoplectia gouldi* zone) in Oklahoma: Rock Crossing of Hickory Creek, about center sec. 25, T. 5 S., R. 1 E., Criner Hills, Carter County; West Spring Creek, east of Pooleville, Murray County.

Discussion.—*Chaulistomella magna* (Schuchert and Cooper) is one of the largest and most robust of described forms. It is further characterized by its unequal costellation, its somewhat swollen pedicle valve, and its rectangular form. It is very close to *C. nitens* from which it differs in its larger size, more unequal costellae, and less strong sulcus. It is also suggestive of *C. mira* but differs in having a more pronounced fold and sulcus and strongly differentiated costellae.

CHAULISTOMELLA MIRA Cooper, new species

Plate 61, D, figures 16-22

Shell large for the genus, length five-sixths the width; hinge narrower than the greatest shell width which is slightly anterior to the middle; sides broadly rounded; anterior margin broadly rounded; anterior commissure gently and broadly uniplicate; lateral commissure with posterior strongly deflected toward the brachial valve; surface multicostellate; costellae fairly uniform in size, separated by very narrow striae; costellae numbering from 10 to 15 in 5 mm. at the front margin.

Pedicle valve uneven in lateral profile, the posterior third nearly flat and the anterior two-thirds flat to gently concave; anterior profile nearly a straight line to very slightly concave; umbonal region gently swollen; fold obsolete; anterior two-thirds and lateral areas flat or barely concave; posterolateral extremities gently rounded and deflected. Interarea strongly apsacline; muscle field bilobate, deeply impressed; pallial marks not well developed.

Brachial valve strongly convex in lateral profile; strongly convex in anterior profile and with long, steep lateral slopes; umbo swollen but without a median depression; median region strongly swollen and with steep lateral slopes; anterior slope long and not so steep as the lateral ones. Umbonal slopes steep to the reflected posterolateral extremities. Brachial interior as usual for the genus.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 29.0 | 29.3 | 36.3 | 30.5 | 11.1 |
| Paratype (pedicle valve 117001c) .. | 28.3 | ? | 34.2 | 30.0 | 4.4 |
| “ (brachial valve 117001d) . | ? | 16.9 | 31.9 | 27.1 | ? |

Types.—Holotype: 117001a; figured paratypes: 117001c,d; unfigured paratype: 117001b.

Horizon and locality.—Bromide formation (Mountain Lake member- cystid bed) in Oklahoma: At the first dam on Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is characterized by its large size, fairly even costellae, and poor development of fold and sulcus. The species is a large and robust one like *C. magna* (Schuchert and Cooper) but differs in its subdued fold and sulcus, fairly uniform costellae, and the lesser development of pallial impressions. It is a larger species than *C. nitens* which, however, has a well-defined fold and sulcus.

CHAULISTOMELLA MUNDULA Cooper, new species

Plate 67, D, figures 24-29; plate 76, C, figures 15-17

Shell of large size for the genus, subrectangular in outline with the width slightly greater than the length; cardinal extremities forming an obtuse angle; sides oblique; anterior margin broadly rounded. Anterior commissure slightly uniplicate; lateral commissure deflected slightly in a brachial direction at the posterior end. Surface multicostellate; costellae rounded, closely spaced, separated by striae narrower than the costellae; about 11 costellae in 5 mm. at the front margin. Concentric fila strong.

Pedicle valve unevenly convex in lateral profile, the posterior half nearly flat, the anterior half gently depressed; anterior profile very slightly convex; umbonal region slightly convex and with an indistinct fold fairly definitely visible in the posterior third to half but barely perceptible or absent in the anterior half to two-thirds. Median and anterior regions slightly swollen, the median region slightly more convex than the anterior one; posterolateral extremities gently deflected toward the brachial; interarea long, nearly catacline; muscle scars deeply impressed, muscle field nearly equal in length and width; anterior indentation moderately deep; adjustor scars fairly large; pallial marks only lightly impressed.

Brachial valve strongly convex in lateral profile with the greatest convexity in the posterior half; anterior half flattened. Anterior profile strongly convex with top somewhat flattened and short but steep lateral slopes. Umbo gently swollen, faintly sulcate; sulcus fairly distinct in the median region but not reaching the anterior margin; median region strongly swollen with steep anterior and lateral slopes. Interarea long, apsacline.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 23.4 | 25.0 | 27.0 | 23.1 | 11.7 |
| Paratype (117000h) | 26.9 | 27.2 | 30.1 | 25.8 | 12.3 |

Types.—Holotype: 117000a; figured paratypes: 110442a,b, 117000e; unfigured paratypes: 117000b-d,f-h.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: In the east side of the road cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; deep well on Jones farm, sec. 22, T. 5 N., R. 3 E., Pottawatomie County, 3,240 to 3,244 feet, Midcontinent Petroleum Corporation well.

Discussion.—This species is characterized by its subquadrate appearance, strongly rounded sides, narrow hinge, and robust form. Its contours are similar to those of *C. quadrata* but differ in the greater convexity of both valves and the much larger size attained.

A pedicle and brachial valve from a deep well in Pottawatomie County is referred here. The pedicle valve agrees fairly well, but the brachial valve is somewhat wider proportionally than is usual in the species.

CHAULISTOMELLA NITENS Cooper, new species

Plate 67, C, figures 17-23

Shell fairly large for the genus, wider than long; hinge about equal to the midwidth; cardinal extremities forming a right angle; sides straight; anterolateral extremities forming a right angle; anterolateral extremities and anterior margin broadly rounded; anterior commissure rectimarginate; lateral commissure deflected toward the brachial valve at its posterior; surface multicostellate; costellae fairly even in size, separated by narrow interspaces, about 10 costellae in 5 mm. at the front margin.

Pedicle valve unevenly convex in lateral profile with the posterior third flatly convex and the anterior two-thirds nearly flat; anterior profile nearly flat; umbo gently swollen, marked by a poorly defined fold extending to the front margin; anterior half depressed; flanks bounding depressed area faintly convex; posterolateral extremities more or less strongly deflected toward the brachial valve; interarea moderately long, nearly catacline; muscle field fairly strongly impressed, length and width about equal, moderately deeply indented anteriorly; adjustor scars small; diductor scars large; pallial marks lightly impressed.

Brachial valve fairly evenly and moderately convex in lateral profile; anterior profile broadly convex; anterior commissure moderately convex, highest in the middle; umbonal, median, and anterior regions fairly strongly swollen; lateral slopes moderately long and steep; umbo sulcate; sulcus narrow, shallow, extending from umbo to anterior margin; interarea moderately long, fairly strongly apsacline. Cardinal process stout; median ridge short; notothyrial platform moderately thickened.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 23.3 | 24.2 | 30.8 | 30.1 | 11.0 |
| Paratype (117003b) | 22.6 | 23.3 | 29.4 | 27.6 | 10.8 |

Types.—Holotype: 117003a; figured paratype: 117003c; unfigured paratype: 117003b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: On the east side of the road cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County.

Discussion.—This species is recognized by its transverse form and general resemblance to *C. magna* (Schuchert and Cooper). It differs from the latter in its smaller size, somewhat more concave pedicle valve and stronger fold and sulcus. It is associated with *C. mundula* but is distinguished by its greater width and stronger costellae.

CHAULISTOMELLA OBESA Cooper, new species

Plate 67, B, figures 8-16

Shell moderately large, length equal to about five-sixths of the width. Cardinal extremities obtusely rounded, strongly deflected toward the brachial valve.

Greatest shell width near the middle. Anterior commissure rectimarginate. Valves covered by rounded costellae as wide or wider than the interspaces, about 7 to 11 costellae in 5 mm. at the front margin.

Pedicle valve in lateral profile gently convex. Median fold slightly developed in the posterior half; umbonal region hemipyramidal, flattened in profile; slopes to cardinal extremities moderate, front half flattened to slightly concave. Interarea long, strongly apsacline.

Brachial valve strongly convex in lateral and anterior profiles with the greatest convexity at the middle. Sulcus shallow, originating at the beak and extending to the front margin or lost just before reaching the margin. Median region of valve strongly swollen in adults with steep slopes in all directions from the middle. Interarea moderately long, curved, apsacline.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 18.7 | 18.8 | 23.2 | 21.2 | 8.9 |
| Paratype (110561a) | 18.6 | 18.7 | 24.2 | 21.6 | 9.3 |

Types.—Holotype: 110562a; figured paratypes: 110561a, 117991a; unfigured paratypes: 110561b-d, 110562b, 117991b,c.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: Sec. 25, T. 2 S., R. 1 E., $\frac{1}{4}$ mile west of U. S. Highway 77; 3 miles north-northeast of Springer, Carter County. Spring Creek, sec. 17. T. 2 S., R. 1 W., Murray County; NW $\frac{1}{4}$ sec. 27, T. 1 S., R. 1 W., midway between Davis and Dougherty, West Spring Creek, east of Pooleville, Murray County.

Discussion.—This species in its nearly biconvex valves strongly suggests the closely similar genus *Multicostella*. Unlike that genus the pedicle valve is depressed at the anterior half, and the fold and sulcus are short and obscure. The species is finely costellate and differs from *C. lebanonensis*, which it approaches in size, by its more convex valves. It is smaller than the other described Oklahoma species except *C. crassa* to which it has no resemblance.

CHAULISTOMELLA RECTANGULATA Cooper, new species

Plate 69, B, figures 7-16

Shell of about medium size for the genus, rectangular in outline; wider than long with the hinge forming the widest part or slightly narrower than width at middle. Sides sloping obliquely in a median direction; anterior margin broadly rounded; anterior commissure rectimarginate to broadly uniplicate; surface multicostellate, costellae narrowly rounded, closely crowded, about 3 in 1 mm. at the front margin.

Pedicle valve variable in lateral profile, posterior half flattened to gently convex; anterior half depressed convex to flat; median fold indistinct and narrow, fairly well defined on the umbo, indistinct in the anterior third; median region flattened; posterolateral extremities deflected slightly toward the brachial valve; interarea long, steeply apsacline to nearly catacline.

Brachial valve strongly convex in lateral profile with the anterior slope flattened but steep; anterior profile strongly convex with steep lateral slopes; median region and umbo swollen; sulcus shallow and narrow, extending from umbo to anterior margin but indistinct in the anterior third; lateral and anterior slopes steep; interarea short, steeply apsacline.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 18.1 | 18.2 | 23.7 | 25.2 | 9.0 |
| Paratype (117005a) | 17.9 | 18.5 | 24.9 | 24.3 | 10.8 |

Types.—Holotype: 117006; figured paratype: 117005a.

Horizon and locality.—Wardell formation (*Hesperorthis*—*Camerella* beds), Evans Ferry section in Tennessee: On U. S. Highway 25E, $\frac{1}{2}$ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; also just above *Hesperorthis* at same locality as preceding; north side of the road, 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—The species is characterized by its rectangular outline, flattish pedicle valve, and strongly convex brachial valve. It resembles *C. lebanonensis* in form and proportions but has a less concave pedicle valve and a much more convex brachial valve. Its compact and strong form separate it from *C. superlata*.

CHAULISTOMELLA RIDLEYENSIS Cooper, new species

Plate 64, A, figures 1-5; plate 67, A, figures 1-7

Small for the genus, subquadrate in outline, wider than long with the hinge forming the widest part or slightly narrower than the midwidth; sides concave just anterior to the cardinal extremities, sloping slightly medianly near the middle; anterolateral extremities somewhat narrowly rounded; anterior margin broadly rounded; anterior commissure uniplicate; surface multicostellate, costellae narrowly rounded, separated by spaces at least equal in width to the costellae; about 9 costellae in 5 mm. at the anterior margin of the brachial valve.

Pedicle valve with variable lateral profile; posterior third moderately convex but anterior two-thirds flat to gently concave; umbonal region slightly swollen; median region flat to concave; lateral areas flat to gently swollen; posterolateral extremities deflected more or less strongly in the direction of the brachial valve; interarea long, strongly apsacline. Muscle field fairly deeply indented anteriorly and with moderately large adjustor scars.

Brachial valve moderately convex in lateral profile; strongly convex in anterior profile with short and steeply sloping sides; median and anterior regions strongly swollen; sulcus originating on the somewhat swollen umbo, extending to the middle but indistinct on the anterior; umbonal slopes short and steep. Interior with short brachioophores, moderately thick notothyrial platform, and large erect cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 15.9 | 16.3 | 17.9 | 15.7 ? | 8.3 |
| Paratype (117008a) | 15.5 | 15.5 | 17.9 | 18.9 | 8.0 |

Types.—Holotype: 117007; figured paratypes: 117008a,b,f; unfigured paratypes: 117008c-e.

Horizon and locality.—Ridley formation (lower third) in Tennessee: At east side of Marshall Knobs, 5 miles south of Murfreesboro, Murfreesboro (15') Quadrangle.

Discussion.—This is a small and compact species characterized by a quadrate form. It differs from all the other species with quadrate outline in its small size. Large specimens are suggestive of *C. lebanonensis* but differ in their squarer outline. The species is a rare one.

CHAULISTOMELLA SUPERLATA Cooper, new species

Plate 66, A, figures 1-9

Shell subrectangular in outline, wider than long and with a variable hinge; sides gently rounded, slightly oblique; anterior margin broadly rounded; anterior commissure rectimarginate; lateral commissure deflected toward the brachial valve at the posterior; surface multicostellate; costellae uneven, about 10 in 5 mm. at the anterior margin.

Pedicle valve unevenly convex in lateral profile, the posterior third very gently convex, the anterior two-thirds moderately concave. Anterior profile gently concave. Umbo slightly swollen, subcarinate; fold narrow, fairly distinct in the posterior region but becoming less distinct anteriorly, then becoming still more indistinct or obsolete; anterior two-thirds concave; flanks bounding concavity forming a fairly prominent oblique fold; posterolateral extremities strongly deflected toward the brachial valve. Interarea long, catacline; muscle field deeply indented anteriorly, deeply impressed and with fairly large adjustor scars. Other pallial marks not distinctly impressed.

Brachial valve moderately strongly convex in lateral profile with the most convex part in the posterior half; anterior half somewhat flattened. Anterior profile strongly convex medianly but with fairly long and moderately steep lateral slopes. Umbonal region swollen, sulcate; sulcus shallow, distinct for two-thirds the valve length, becoming indistinct or obsolete in the anterior third. Median region swollen; lateral and umbonal slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.8 | 19.6 | 24.6 | 24.5+ | 9.4 |
| Paratype (110506b) | 15.0 | 16.6 | 20.4 | 20.4 | 7.0 |

Types.—Holotype: 110506a; figured paratypes: 110506b,d-f; unfigured paratypes: 110506c,g.

Horizon and locality.—Ridley formation in Georgia: On U. S. Highway 27

just northwest of Chickamauga Creek, Kensington (T.V.A. 106-SE) Quadrangle.

Discussion.—This species has the outline and profile of *Campylorthis* and thus suggests *C. lebanonensis*. It differs in being a much larger shell with stronger ornamentation and somewhat less deep brachial valve.

CHAULISTOMELLA sp. 1

Plate 63, A, figures 1-7

The figured specimens are young because a brachial valve in the collection is nearly twice the size of the complete specimen. The species is characterized by its subquadrate form, the length and width being about equal. The sides are subparallel; the costellae are closely crowded with about 12 in 5 mm. in the young complete specimen but 10 in 5 mm. at the front of the large brachial valve. The pedicle valve is unusually convex for the genus, but that may be an indication of the youth of the specimen. The brachial valve is strongly convex. The species resembles *C. mundula* in outline but is a much more robust form with a more convex pedicle valve. The immature complete specimen measures in mm.: Length of pedicle valve 16.4, brachial length 16.5, width at middle 19.4, thickness 7.9.

Figured specimens.—117990a,b.

Horizon and locality.—Carters formation (*Oxoplectra* bed) in Alabama: Quarry 0.3 mile north of Gate City, Leeds (15') Quadrangle.

CHAULISTOMELLA (?) sp. 2

Plate 126, G, figures 36-40

Under this designation is placed a small lot of shells that may have other generic affinities. They are described because they occur in the Oranda formation and may represent the end of a dinorthisid line if correctly assigned. Proper generic definition will not be possible until the pedicle interior as well as the brachial interior is known.

Small for the genus, subrectangular with the width greater than the length. Sides rounded; anterior margin broadly rounded; hinge narrower than the mid-width. Exterior finely costellate and with the striae between the costellae occupied by prominent concentric fila.

Pedicle valve moderately concave in lateral profile; broadly concave in anterior profile. Umbo narrowly convex, the convexity continued anteriorly as a low fold. Flanks bounding fold gently concave. Interarea long and strongly apsacline.

Brachial valve gently convex in lateral profile and with the maximum convexity in the posterior half; anterior profile bilobed; sulcus originating at the umbo, widening and deepening to the anterior margin where it occupies about one-third the width. Flanks bounding sulcus somewhat narrowly convex; posterolateral slopes short and steep; posterolateral extremities flattened. Cardinal process slender; notothyrial platform moderately thickened. Sockets deep, brachipophores short and blunt.

Measurements in mm.—

| | Brachial length | Length | Midwidth | Hinge width | Height | Thickness |
|-----------------------------|-----------------|--------|----------|-------------|--------|-----------|
| Pedicle valve (117009f).... | ? | 11.5 | 15.8 | ? | ? | ? |
| Brachial valve (117009a).. | 9.2 | ? | 13.5 | 10.7 ? | ? | 2.1 ? |

Figured specimens.—117009a,b,f.

Horizon and locality.—Oranda formation in Virginia: In the railroad cut $\frac{1}{2}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Family PLECTORTHIDAE Schuchert and Cooper, 1931

Biconvex or convexi-concave Orthacea having a variable but usually somewhat cordate muscle area in the pedicle valve; brachial valve having the brachio-phores supported by convergent plates which unite with the floor of the valve on each side of the cardinal process. Sockets defined by fulcral plates. Cardinal process simple and usually having a compressed, crenulated myophore. Delthyrium and notothyrium usually unmodified.

Subfamily PLECTORTHINAE Schuchert, 1929

Coarse and fine-ribbed Plectorthidae having wide hinge lines and unequal interareas.

Genus DESMORTHIS Ulrich and Cooper, 1936

Desmorthis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 624, 1936; Geol. Soc. Amer. Special Pap. 13, p. 158, 1938.

DESMORTHIS COSTATA Cooper, new species

Plate 50, J, figures 42-46

Shell of about usual size for the genus, wider than long, with the greatest width at about the middle; sides gently rounded; anterior margin broadly rounded; anterior commissure rectimarginate. Surface costae, 36 along the margin of an adult shell. One generation intercalated near the middle; costae narrow, separated by spaces about equal in width to the width of the costae.

Pedicle valve gently convex in lateral profile with the greatest depth located in the postumbonal region; anterior profile fairly strongly convex with the median region somewhat narrowly rounded; umbonal and median regions swollen; lateral areas full and with short, steep slopes to the margins. Interarea long, curved, apsacline.

Brachial valve with most convex part in the posterior region when viewed in lateral profile; anterior profile broadly but gently convex. Umbo swollen; sulcus originating at the umbo, shallow, narrow but extending to the front margin. Flanks bounding sulcus gently swollen; slopes to posterolateral extremities short and steep.

Measurements in mm.—Holotype, length 5.9, brachial length 5.2, width 7.3, hinge width 5.7, thickness, 2.5.

Types.—Holotype: 110813a.

Horizon and locality.—Joins formation in Oklahoma: In SW $\frac{1}{4}$ sec. 2, T. 1 S., R. 1 W., about 4 miles east of Hennepin, Murray County; Falls Creek, Murray County; $\frac{1}{4}$ mile west of Highway 77, sec. 25, T. 2 S., R. 1 E., Carter County; bed 3 of section, 1 mile west of Mill Creek, Johnston County.

Discussion.—This species differs from *D. nevadensis*, also from the Joins formation, in its stronger and more distant ribbing. Although *D. costata* has some intercalated ribs, the surface is never as closely covered as in *D. nevadensis*.

DESMORTHIS NEVADENSIS Ulrich and Cooper

Plate 50, H, figures 35-39; plate 83, A, figures 1-15

Orthis perveta WALCOTT (not Conrad), U. S. Geol. Surv. Mon. 8, p. 72, pl. 11, figs. 3, 3a, b, 1884.

Desmorthis nevadensis ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 159, pl. 30A, figs. 1-16, 1938.

Types.—Holotype: 91344a; paratypes: 91344b-k, 91342a-d; complete specimen figured by Walcott as *Orthis perveta*: 17235; figured hypotype: 110817a; figured specimen: 110806a.

Horizon and locality.—Upper Pogonip group (*Desmorthis* zone) in Nevada: At the west end of Lone Mountain, 18 miles northwest of Eureka, Roberts Mountains (1°) Quadrangle.

Joins formation in Oklahoma: SW $\frac{1}{4}$ sec. 2, T. 1 S., R. 1 W., 4 miles east of Hennepin, Murray County; Henryhouse Creek, Murray County; $\frac{1}{4}$ mile west of U. S. Highway 77, sec. 25, T. 2 S., R. 1 E., Carter County.

Genus PLECTORTHIS Hall and Clarke, 1892

Plectorthis HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 194, 221, 1892.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 57, 1932.

PLECTORTHIS AUSTRALIS Cooper, new species

Plate 71, E, figures 21-26

Shell of about medium size for the genus, subquadrate in outline, slightly wider than long; hinge narrow; greatest width at about the middle; sides and anterior margin gently rounded; anterior commissure rectimarginate. Surface marked by about 44 narrowly rounded, elevated costae intercalated in 2 generations and an incipient one appearing at the front margin.

Pedicle valve gently convex in lateral profile with the greatest convexity appearing just anterior to the umbo; anterior broadly convex with the median region somewhat narrowly rounded; umbo and median region somewhat narrowly swollen; anteromedian region and flanks moderately inflated; lateral slopes to margin long and moderately steep. Interarea short, curved, gently apsacline.

Brachial valve gently convex in lateral profile with the maximum depth occurring at about the middle; anterior profile broadly and gently convex and with median region depressed slightly into a shallow sulcus. Umbo moderately swollen; sulcus originating on the umbo, shallow, widening but not deepening to the

anterior margin where it is occupied by about 4 costae. Flanks bounding sulcus gently swollen with short and gentle slopes to the margins.

Measurements in mm.—Holotype, length 12.7, brachial length 12.3, width 15.0, hinge width 11.2, thickness 5.9.

Types.—Holotype: 117019a; unfigured paratypes: 117019b-f.

Horizon and locality.—Little Oak formation in Alabama: From a cut on U. S. Highway 31, $\frac{1}{2}$ mile north of Pelham, Bessemer Iron District (15') Quadrangle.

Arline formation in Tennessee: Along wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is characterized by its subcircular outline, the scattered and irregular intercalation, and the elevated, narrowly rounded costellae. It is most suggestive of *P. compacta* from Tennessee but differs in having a much more compressed profile, more slender costae, and less convex valves. A few specimens from Friendsville, Tenn., agree with the Alabama species in the slender character of the costae.

PLECTORTHIS COMPACTA Cooper, new species

Plate 84, B, figures 6-17

Shell of moderate size for the genus, width about one-quarter greater than the length. Hinge narrower than the greatest shell width and about equal to the length. Greatest width at about the middle. Cardinal extremities obtuse; lateral margins narrowly rounded; anterior margin gently rounded to nearly straight. Surface costate, with 35 to 38 costae. The costae on the flanks turn posterolaterally at about two-thirds their length from the beak. In the region of the cardinal extremities a few costae are intercalated, and occasional costae are intercalated on the body of the shell.

Pedicle valve strongly and evenly convex in lateral profile; broadly and gently convex in anterior profile. The greatest convexity at the middle in both profiles. Beak short and stout, incurved; umbo swollen; umbonal slopes moderately steep; gently concave. Flanks and middle part gently swollen; fold defined only as a gentle median swelling, usually inconspicuous. Interarea short, moderately apsacline; slightly curved. Muscle field heart shaped, dental plates well developed.

Brachial valve slightly less convex and deep than the pedicle valve; umbo moderately swollen. Sulcus originating on the umbo and extending to the front margin or scarcely defined. Sulcus, when present, shallow, widening anteriorly and occupied by 3 to 6 costae. Flanks moderately swollen with moderately steep and short slopes to the lateral margins and cardinal extremities. Interarea short and curved, generally apsacline. Notothyrial cavity deep, cardinal process high, slender, median ridge reaching the middle; brachiophores short, curved; brachio-phore supports well developed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.3 | 11.7 | 15.3 | 11.9 | 7.4 |
| Paratype (110821s) | 15.3 | 14.5 | 18.5 | 14.0 | 9.1 |
| “ (110821t) | 14.0 | 13.7 | 17.6 | 13.4 | 9.0 |
| “ (110821u) | 13.4 | 12.9 | 16.2 | 9.7 | 7.8 |

Types.—Holotype: 110821r; figured paratypes: 110821n,o,q,s; unfigured paratypes: 110821a-m,p,t,u.

Horizon and locality.—Arline formation in Tennessee: Along wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; McMullens, Meadow (T.V.A. 139-NW) Quadrangle.

Discussion.—This species is fairly common at Friendsville and can be recognized by its compact form, strongly convex valves, and thick costae. The last-named feature and the depth of the valves distinguish it from *P. australis*. The species is suggestive of *P. ponderosa* in its compact form but does not reach the large size of that species. It is quite unlike any other species described herein, which in general remind one more of *P. plicatella* than the compact forms.

PLECTORTHIS LEBANONENSIS Cooper, new species

Plate 81, D, figures 15-17

Shell fairly large for the genus, wider than long; hinge narrow; valves unequally convex, the pedicle valve with the greater convexity. Sides gently rounded; anterior margin broadly rounded; maximum width at about the middle. Surface marked by about 30 narrowly rounded costae separated by spaces equal to or slightly greater than the width of the costae, those of the brachial valve slightly more distantly spaced than those of the pedicle valve. Interspaces marked by fine, elevated threads.

Pedicle valve strongly convex in lateral profile with the greatest convexity in the posterior region; anterior profile strongly convex; umbonal and median regions inflated; lateral areas somewhat inflated and with moderately steep but short slopes. Interarea curved, apsacline.

Brachial valve gently convex in lateral profile; broadly and gently convex in anterior profile; sulcus originating at the umbo, shallow and extending to the anterior margin; flanks bounding sulcus gently swollen; lateral slopes moderately long but gentle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.3 | ? | 10.2 | 8.4 | 2.3 |
| Paratype (110834a) | ? | 8.7 | 12.0 | 11.0 | 1.2 ? |

Types.—Holotype: 110834c; figured paratypes: 110834a,b.

Horizon and locality.—Lebanon formation in Tennessee: On Tennessee Highway 16, 3.6 miles northwest of junction of Tennessee Highway 16 and U. S. Highway 241, Shelbyville, Bedford County; quarry on U. S. Highway 41, 11.7 miles southeast of Murfreesboro, Rutherford County.

Discussion.—The specimens on which this species is based leave much to be desired, but the species is fairly distinctive in the slender and closely crowded costae. Most of the specimens are young, but a few indicate that the species must have reached an adult width of nearly 20 mm. The species is characterized, besides the costae already mentioned, by the strongly convex pedicle valve and

the gently convex brachial valve. In size it approaches *P. transversa* but differs in having a less carinate pedicle valve and less transverse outline. It differs from *P. tenuis* in possessing much stronger costae. It is also suggestive of *P. pennsylvanica* but has a more convex pedicle valve.

PLECTORTHIS MAZOURKAENSIS Phleger

Plectorthis mazourkaensis PHLEGER, Bull. S. California Acad. Sci., vol. 32, pt. 1, p. 9, pl. 2, figs. 3-5, 1933.

Horizon and locality.—Mazourka formation in California: Mazourka Canyon, about $\frac{1}{2}$ mile below the Lead Canyon trail, Inyo Mountains.

PLECTORTHIS OBESA Cooper, new species

Plate 92, F, figures 34-38; plate 269, A, figures 1-5

Shell large for the genus, subequally biconvex; hinge narrow; greatest width at the middle; sides and anterior margin rounded; anterior commissure rectimarginate; surface provided with 27 narrowly rounded, elevated costae separated by spaces wider than the width of the costae. Each costa bearing a double row of pits on its surface.

Pedicle valve moderately convex in lateral profile, the median region somewhat flattened but the anterior and posterior thirds convex. Anterior profile broadly and moderately convex. Umbonal region swollen; entire valve inflated but with steep posterolateral slopes. Interarea short, apsacline.

Brachial valve moderately convex but with the posterior and anterior thirds somewhat abruptly curved. Anterior profile broadly convex with the median region somewhat flattened and the sides short and steep. Entire valve inflated; sulcus originating on the umbo and extending to the anterior margin, shallow and narrow and occupied by 2 costae. All slopes to the margins precipitous.

Measurements in mm.—Holotype, length 17.7, brachial length 16.9, width 19.2, hinge width 13.4, thickness 11.9.

Types.—Holotype: 117020, figured paratype 124233a.

Horizon and locality.—Dark shale under Eureka quartzite, in Nevada: Ridge east of Martin Ranch; under 2 knobs of Eureka quartzite, north side canyon, 3.1 miles N. 32° E. of Blair (Segura) Ranch, Antelope Mountains, Roberts Mountains (1°) Quadrangle.

Discussion.—This species suggests *P. ponderosa*, but it does not attain the large size of that species and is a thicker-shelled and much deeper species.

PLECTORTHIS PATULA (Phleger)

Plectorthis patulus PHLEGER, Bull. S. California Acad. Sci., vol. 32, pt. 1, p. 10, pl. 2, figs. 1-2, 1933.

Horizon and locality.—Mazourka formation in California: In Mazourka Canyon, about $\frac{1}{2}$ mile below the Lead Canyon trail, Inyo Mountains.

PLECTORTHIS PENNSYLVANICA Cooper, new species

Plate 92, G, figures 39-44

Shell of about medium size for the genus, wider than long; hinge narrower than the greatest width which is at the middle; sides narrowly rounded; anterior margin broadly rounded; anterior commissure rectimarginate. Surface marked by 29 narrowly rounded costae equal in width to the width of the spaces between them. Interspaces marked by strong, distant fila.

Pedicle valve with gentle lateral profile having the maximum convexity at about the middle; anterior profile broadly convex and moderately humped in the middle; umbo somewhat narrowly swollen, the swelling extending to the middle of the valve but lessening anteriorly; flanks and lateral areas descending gently to the margins. Interarea, short, curved, strongly apsacline.

Brachial valve very gently convex in lateral and anterior profiles; umbo sulcate, sulcus shallow from umbo to margin but widening broadly; sulcus occupied by 4 costae. Flanks bounding sulcus gently swollen; lateral slopes long and gentle.

Measurements in mm.—Holotype, length 10.6, brachial length 9.7, width 13.7, hinge width 10.9, thickness 4.9.

Types.—Holotype: 117021A; unfigured paratype: 117021B.

Horizon and locality.—Rodman member of Nealmont formation in Pennsylvania: On the east side south quarry at Sparr, Huntingdon (15') Quadrangle.

Discussion.—This species suggests the *P. plicatella* group of the higher parts of the Trenton limestone. It differs from that species, however, in its proportionately wider hinge, less convex valves, and more closely spaced costae. It is a larger species than *P. symmetrica* with wider hinge, somewhat less numerous costae, and proportionately less convex valves.

PLECTORTHIS PONDEROSA Cooper, new species

Plate 83, C, figures 22-32; plate 84, E, figures 24-32

Shell large for the genus, subquadrate in outline; hinge narrow; greatest shell width at the middle; sides broadly rounded; anterolateral extremities narrowly rounded; anterior margin gently curved; anterior commissure rectimarginate; surface marked by about 30 strong, direct costae.

Pedicle valve fairly strongly convex in lateral profile with the greatest convexity just anterior to the umbo; anterior half somewhat flattened; anterior profile a broad arch; umbo and median region strongly swollen; lateral area swollen and with steep slopes to the lateral margin; interarea strongly curved, gently apsacline. Muscle area small; diductor scars long and narrow; adductor track moderately wide.

Brachial valve with gentle convexity in lateral profile, its depth considerably less than that of the pedicle valve; median region swollen; sulcus shallow and narrow, originating at the umbo and widening to the front margin where it is inconspicuous. Flanks bounding sulcus broadly swollen; lateral slopes moder-

ately broad and gently sloping to the margins. Cardinal process thick and bulbous; brachioophore plates short and stout.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 16.9 | 15.5 | 20.3 | 14.7 | 9.9 |
| Paratype (117022b) | 20.4 | 19.0 | 24.4 | 17.9 | 11.2 |

Types.—Holotype: 117022a; figured paratypes: 110837a-d, 117022b; unfigured paratype: 110837e.

Horizon and locality.—Basal Martinsburg formation (basal part with *Brongniartella* referable to the Salona formation) in Virginia: On Virginia County Highway 617=910, 0.15 miles north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species can be readily recognized by its large size and coarse costae. It is unlike any other species described in this monograph except *P. obesa*. That species, however, is a much deeper one which, as far as known, does not attain the large size of *P. ponderosa*.

PLECTORTHIS PUNCTATA Cooper, new species

Plate 84, D, figures 19-23; plate 84, F, figures 33-35

Shell small for the genus, wider than long; hinge narrow; valves subequally convex, the pedicle valve having the greater depth; anterior commissure broadly unisulcate; sides rounded; anterior margin somewhat truncated. Surface marked by 31 costae at the front margin; some costae on the flanks bifurcating or intercalated. Costae bearing 2 rows of prominent pits.

Pedicle valve moderately convex in both profiles; median region swollen; lateral slopes long and moderately steep. Brachial valve gently convex in lateral profile; broadly convex in anterior profile; sulcus originating at the umbo, widening anteriorly, prominent in the young, becoming shallow anteriorly and disappearing in adults. Lateral regions swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | ? | 8.1 | 11.0 | 7.8 ? | 1.8 ? |
| Paratype (117024) | 6.0+ | 6.4 | 8.5 | 6.2 | 3.1 |

Types.—Holotype: 110836a; figured paratypes: 117023b, 117024; unfigured paratypes: 110836b, 117023a.

Horizon and locality.—Tulip Creek formation in Oklahoma: On West Spring Creek, NW $\frac{1}{4}$ sec. 6, T. 2 S., R. 1 W.; NE corner sec. 1, T. 2 S., R. 2 W., 2 $\frac{1}{2}$ miles east of Pooleville, Murray County; first creek east of U. S. Highway 77, SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County.

Discussion.—This species is similar to *P. symmetrica* in size and general form but differs in having a more strongly convex brachial valve characterized by 2 rows of pits on each side of the costae.

PLECTORTHIS SYMMETRICA Cooper, new species

Plate 83, B, figures 16-21; plate 92, H, figures 45-50

Shell of about medium size for the genus, wider than long and with the greatest width at about the middle. Hinge width about three-fourths the shell width. Cardinal extremities obtuse. Lateral margins somewhat narrowly rounded; anterior margin broadly rounded. Surface costate; costae of pedicle valve slightly wider than those of brachial valve, with interspaces slightly narrower than the costae. Brachial costae narrower than those of the pedicle valve and the interspaces slightly wider than the costae. About 32 costae. Interspaces marked by occasional fine costellae and concentric fila. Surfaces of costae smooth.

Pedicle valve moderately convex with the greatest convexity in the umbonal region; anterior profile narrowly rounded medianly with moderate lateral slopes; umbo gently convex; beak broadly obtuse and protruding slightly posterior to the posterior margin. Median region somewhat swollen; lateral and anterior slopes moderately steep. Posterolateral slope to cardinal extremities slightly concave and steeper than the slopes anterior to them. Interarea short, curved, apsacline.

Brachial valve gently and evenly convex in lateral profile and with the greatest convexity at about the middle; anterior profile with a gentle, shallow median depression and slightly swollen flanks. Umbo sulcate; sulcus shallow, poorly defined and extending for about one-half to three-quarters the valve length. Flanks slightly swollen, posterolateral areas slightly flattened. Anterior half somewhat flattened; interarea short, orthocline.

Pedicle interior with short, narrowly divergent dental plates bounding a short muscle field. Brachial interior with widely divergent, flat, and broad brachio-phores braced by short, convergent brachiophore supporting plates. Cardinal process low but with a hebertelloid myophore.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.2 | 8.6 | 11.4 | 8.8 | 4.7 |
| Paratype (110824b) | 8.4 | 8.2 | 11.0 | 8.8 | 4.8 |

Types.—Holotype: 110824a; figured paratypes: 110828a,d; unfigured paratypes: 110824b-f, 110828b,c.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Carter County, Okla.: At Rock Crossing of Hickory Creek, near center sec. 35, T. 5 S., R. 1 E.; NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E.

Discussion.—This species in its form suggests *P. compacta*, but it does not reach the large size and rotund form of that species. The valves of *P. compacta* are subequal in depth, whereas the brachial valve of *P. symmetrica* is shallow, the pedicle valve having the greater depth. Comparison with *P. pennsylvanica* is made under that species.

PLECTORTHIS TENUIS Cooper, new species

Plate 81, E, figures 18-29

Shell large for the genus, slender in lateral profile; valves subequally biconvex but the pedicle valve with the greater depth; hinge narrow; greatest width at about the middle; sides somewhat narrowly rounded; anterior margin broadly rounded; anterior commissure rectimarginate. Surface marked by about 42 narrowly rounded costae.

Pedicle valve with moderately convex lateral profile; anterior profile broadly convex and not conspicuously swollen in the middle; umbonal region somewhat swollen; median region swollen and with long gentle slopes to the lateral margins. Interarea short, apsacline, slightly curved; muscle field small, narrow; diductor impressions deeply impressed; adductor track slightly elevated.

Brachial valve with moderately convex lateral profile; anterior profile broadly convex and with a slight median depression. Sulcus originating on the umbo, shallow and widening anteriorly to the front margin; occupied by 4 costae at the front. Flanks bounding sulcus gently swollen; posterolateral slopes short, moderately steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.8 | 10.4 | 13.7 | 10.4 | 4.5 |
| Paratype (117027) | 15.8 | 15.6 | 22.3 | 15.0 | 6.8 ? |

Types.—Holotype: 117028c; figured paratypes: 117027, 117028a,b,d.

Horizon and locality.—Benbolt formation (base) in Virginia: 0.2 mile south of the middle fork of Moccasin Creek, 1½ miles due south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; north side of U. S. Highway 19, 1¼ miles southeast of Hansonville Post Office, Brumley (T.V.A. 205-SE) Quadrangle; south side of Mount Hagan School, southeast corner of northeast subquad., Hilton (T.V.A. 197-NW) Quadrangle.

Benbolt formation in Tennessee: 0.1 to 0.2 mile north of the road 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species is characterized by its slender form and fine, numerous costae. It is a fairly wide species and is thus suggestive of *P. transversa*, but that species is more strongly costate. It is actually wider and longer than *P. compacta* but is easily differentiated by its compressed profile and slender costae.

PLECTORTHIS TRANSVERSA Cooper, new species

Plate 84, A, figures 1-5

Shell of about usual size for the genus, subelliptical in outline, lenticular in profile, with narrowly rounded lateral margins and a very gently rounded anterior margin. Hinge equal in width to about two-thirds the maximum width which is at the middle. Surface ornamented by 34 narrow, elevated, rounded costae which appear in 3 generations by intercalation.

Pedicle valve in lateral profile most convex on the umbo and slightly posterior

to the middle of the valve. Anterior profile with flanks sloping gently away from the swollen median region. Fold barely perceptible. Beak slightly incurved; interarea moderately long, apsacline, slightly curved.

Brachial valve with lateral profile having its greatest convexity at about the middle. Sulcus originating on the umbo near the beak and extending to the front margin where it is visible as a slight depression occupied by 5 costae. Flanks bounding sulcus slightly swollen and lateral slopes of flanks to the posterolateral margin short and consequently moderately steep.

Measurements in mm.—Holotype, length 13.2, brachial length 12.1, width 18.1, hinge width 12.4, thickness 6.3.

Types.—Holotype: 98181.

Horizon and locality.—Arline formation in Virginia: Quarry at Marion, Marion (T.V.A. 218-SE) Quadrangle; Ward Cove formation 0.4 mile northeast of Jeff Gillespie's in Thompson Valley, southwest of Tazewell, Pounding Mill (15') Quadrangle.

Discussion.—This species is characterized by its transversely elliptical outline. It approaches *P. compacta* in size but is more slender and less coarsely costate. This species is also suggestive of *P. plicatella* of the Trenton but differs in its slender profile and more slender costae.

PLECTORTHIS sp. 1

Three specimens from the *Nidulites* zone of the Chambersburg limestone indicate a species suggesting *P. lebanonensis* in the form and ribbing of the pedicle valve, but the brachial valve is shallow and contains numerous incipient intercalations at the front margin.

Measurements in mm.—

| | Length | Width |
|-----------------------------|--------|-------|
| Pedicle valve 117026a..... | 11.7 | 14.7 |
| Brachial valve 117026b..... | 10.5 | 14.3 |

Described specimens.—117026a,b.

Horizon and locality.—Shippensburg formation (Pinesburg member-*Nidulites* zone) in Pennsylvania: 3½ miles north of Greencastle, Chambersburg (15') Quadrangle.

PLECTORTHIS sp. 2

Plate 84, C, figure 18

A *Plectorthis* of uncertain nature occurs in the chert of the Murfreesboro formation at the type locality. The specimens consist of three partially buried exteriors and the posterior end of a brachial interior which shows the characteristic cardinalia. The specimens are so strongly silicified that accurate description is not possible.

Figured specimen.—110835a.

Horizon and locality.—Murfreesboro formation in Tennessee: From excavation of new armory building at junction of west fork of Stone River and U. S.

Highway 70, 1½ miles northwest of Murfreesboro, Murfreesboro (15') Quadrangle.

Genus **DOLEROIDES** Cooper, 1930

Doleroides COOPER, Journ. Paleont., vol. 4, pp. 375, 382, 1930.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 63, 1932.

DOLEROIDES COMPRESSUS Cooper, new species

Plate 96, B, figures 22-38

Small for the genus, wider than long, broadly elliptical in outline; hinge narrower than the midwidth; greatest width slightly anterior to the middle; sides nearly straight and slightly oblique outward; anterolateral extremities narrowly rounded; anterior margin broadly rounded; anterior commissure rectimarginate; surface multicostellate; costellae unequal in size, numerous intercalated and usually fasciculate, 10 to 14 in 5 mm. at the front margin.

Pedicle valve with greater depth than the brachial valve, moderately convex in lateral profile; strongly convex in anterior profile with the median region narrowly rounded; umbonal region narrowly swollen; median region swollen with moderately steep and fairly long slopes to the margins. Interarea curved, apsacline; muscle impression fairly long and with fairly wide diductor scars; dental plates short; pallial impressions not preserved.

Brachial valve gently convex in both profiles and with the greatest convexity in the median region. Sulcus originating on the umbo, short and shallow and confined to the posterior half; sulcus barely perceptible on the anterior half of the valve; flanks gently inflated; lateral slopes short and gentle. Cardinal process a thin septum; notothyrial chamber moderately deep; brachiophores short; supporting plates depressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.6 | 11.0 | 14.4 | 10.7 | 5.3 |
| Paratype (110607b) | 10.8 | 10.3 | 12.9 | 9.8 | 5.4 |
| “ (110605a) | 13.1 | 12.0 | 15.3 | 10.0 | 7.5 |

Types.—Holotype: 110607c; figured paratypes: 110596a, 110607a,d-f; unfigured paratypes: 110596b-h, 110605a, 110607b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: On the east side of Oklahoma Highway 18, sec. 11, T. 1 S., R. 3 E., 1.8 miles south of Sulphur, Murray County.

Discussion.—This species is abundant in the road cut south of Sulphur but was not seen at the same horizon on Spring Creek. The complete specimens illustrated are adults, but they are young ones. The species evidently attains a size nearly double that of the figured specimens but retains its compressed form except for a few occasional obese specimens. The compressed form is the chief characteristic of the species and differentiates it from the similar *D. oklahomensis*.

DOLEROIDES CRASSUS Cooper, new species

Plate 95, A, figures 1-5

Shell of about medium size for the genus, subquadrate in outline; hinge narrow; greatest width anterior to the middle; sides oblique outward; anterolateral extremities narrowly rounded; anterior margin broadly rounded; anterior commissure rectimarginate. Costellae appearing in 4 generations; about 9 to 10 costellae in 5 mm. at the front margin.

Pedicle valve about equal in depth to that of the brachial valve; moderately convex in lateral profile but with the anterior third somewhat flattened; beak somewhat elongated; umbo not differentiated from the inflated median region; sides somewhat inflated; posterolateral slopes short and steep.

Brachial valve fairly strongly convex and with the maximum curvature at the middle; anterior profile broadly convex with a flattened median region and short, steep lateral slopes; median ridge shallow, narrow, and confined to the posterior half; flanks moderately swollen; posterolateral slopes short and steep.

Measurements in mm.—Holotype, length 15.5, brachial length 14.7, width 18.3, hinge width 13.2, thickness 9.0.

Types.—Holotype: 110742b; unfigured paratype: 110742a.

Horizon and locality.—Ridley formation in Georgia: from a road cut on U. S. Highway 27 just northwest of Chickamauga Creek, Kensington (T.V.A. 106-SE) Quadrangle.

Discussion.—This species is characterized by its narrow hinge that differentiates it from *D. extensus* with which it occurs. Its form is suggestive of that of *D. gibbosus* of the Upper Mississippi Valley and Canada, but it differs from that species in its rectimarginate anterior commissure, less deep valves, and somewhat stronger costellae.

DOLEROIDES EXTENSUS Cooper, new species

Plate 95, B, figures 6-20

Shell fairly large for the genus, somewhat rectangular in outline; wider than long, with the hinge only slightly less than the midwidth; sides gently rounded; anterior margin broadly rounded; anterior commissure rectimarginate; costellae thick, narrowly rounded, appearing in several generations and numbering about 11 in 5 mm. at the front of the holotype.

Pedicle valve slightly deeper than the brachial valve, gently convex in lateral profile; broadly convex in anterior profile with the median region somewhat narrowly rounded; beak low; umbo somewhat inflated; median region moderately swollen; lateral areas gently convex and with long, gentle slopes to the margins. Interarea apsacline; interior with short and flaring dental plates; umbonal cavities shallow; muscle field extending nearly to the middle, typical for the genus.

Brachial valve gently convex in lateral profile; anterior profile broadly convex with gently depressed or flattened median region and short, steep lateral slopes; umbo and median region gently swollen; sulcus shallow and narrow, originating on the umbo but extending only to the middle where it merges with the some-

what swollen anterior slope; lateral areas gently swollen; interior with thick notothyrial platform and low median ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 15.5+ | 14.7 | 19.7 | 17.2 | 7.6 |
| Paratype (117031) | 12.2 | 11.5 | 16.0 | 12.9 | 7.0 |

Types.—Holotype: 117030; figured paratypes: 117031, 117032a,b.

Horizon and locality.—Ridley formation on the Kensington (T.V.A. 106-SE) Quadrangle in Georgia: On U. S. Highway 27 just northwest of Chickamauga Creek; quarry on the west side of the road $1\frac{1}{2}$ miles south-southeast of Cove Church, 5 miles south of Chickamauga.

Discussion.—This species is characterized by its transversely subrectangular outline and strong costellae. It differs from *D. regularis* in its extended outline and wide hinge as well as stronger costellae. It differs from *D. winchelli* Cooper which is also a wide-hinged species in its almost complete lack of a fold and sulcus and the rectimarginate anterior commissure. The species was seen only in Georgia.

DOLEROIDES GIBBOSUS (Billings)

Plate 93, B, figures 8-14

Orthis gibbosa BILLINGS, Geol. Surv. Canada, Rep. Progress for 1856, p. 296, 1857.

Doleroides gibbosus (Billings) COOPER, Journ. Paleont., vol. 4, No. 4, p. 375, 382; pl. 35, figs. 5-7; pl. 37, fig. 2, 1930.—WILSON, A. E., Geol. Surv. Canada Bull. 8, p. 49, pl. 3, figs. 27a, b, 1946.

Subcircular to subelliptical in outline, lenticular in profile, the brachial valve generally having the greater depth; hinge narrower than the greatest shell width which is located at or anterior to the middle. Anterior margin broadly rounded, lateral margins convex. Anterior commissure more or less strongly uniplicate. Surface multicostellate, costellae subequal, 9 in 5 mm. in the sulcus; costellae on the flanks alternating in size.

Pedicle valve moderately convex in lateral profile with the greatest convexity located in the posterior half; sulcus originating anterior to the umbo, generally wide and shallow but variable, some specimens having a fairly deep and narrow sulcus. Flanks gently convex with steep slopes to the cardinal extremities. Interarea moderately long, apsacline.

Brachial valve evenly and moderately convex with the greatest convexity in the median region; anterior profile broadly convex with the midregion flattened. Umbo marked by a shallow and narrow sulcus, usually indistinct; fold originating posterior to the middle, low, flattened, often not distinctly marked from the flanks except at the anterior. Flanks gently convex with steep slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (110588a) | 17.6 | 16.0 | 20.8 | 14.3 | 10.6 |
| " (24772a) | 16.4 | 15.4 | 19.3 | 14.0 | 10.7 |
| " (24772b) | 18.4 | 16.6 | 21.8 | 13.7 | 12.9 |

Types.—Figured hypotypes: 24772a, 24760; unfigured hypotypes: 24772b, 110588a.

Horizon and locality.—Decorah formation (Spechts Ferry member) in Minnesota: At Fountain, Fillmore County; Chatfield, Fillmore County; St. Paul; Minneapolis; Elmira, Olmsted County.

Rockland formation in Ontario, Canada: At Gloucester and near Ottawa.

Rockland formation in New York: At Watertown and 1 mile east of Dexter.

Macy formation (Zell member) in Missouri: On the old road 1 mile northwest of Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 27 N., R. 9 E., Weingarten (15') Quadrangle.

Discussion.—This species is distinguished by its fairly large size and the strong development of the fold and sulcus particularly in the anterior third or half. As here identified the species is very variable as to outline and profile, development of fold, and sulcus and ornamentation. As would be expected, variations in profile are common and may have nothing to do with the biological characters of the shells. Some of the specimens occur in soft shales and may be somewhat flattened. Variations in outline are not generally due to distortion, and specimens in all types of matrix showed a variation in the relation of length to width. Some specimens are distinctly more rounded than others, and in the round ones the cardinal extremities are generally much rounded, a feature that emphasizes the rotundity of the outline. Some specimens are distinctly shouldered and have cardinal extremities approaching a right angle. Most of the specimens referred to this species have a fairly narrow fold and sulcus, but in a few of them, the sulcus may occupy as much as half the shell width. Specimens of this type occur in Minnesota and Ontario, but none was seen in the Plattin group. The Minnesota specimens vary from the Canadian ones in the character of the ornamentation, particularly the costellae occupying the sulcus. In the Minnesota forms these costellae are generally nearly uniform in size, but in the Canadian specimens a tendency to alternation of fine and strong costellae is present. Despite these variations the writer was unable to find suitable differences on which to base additional species.

DOLEROIDES IRREGULARIS Cooper, new species

Plate 95, E, figures 31-39

Shell small for the genus, wider than long, with the greatest width located anterior to the middle; hinge narrow; sides oblique outward; anterolateral extremities narrowly rounded; anterior margin nearly straight; anterior commissure slightly uniplicate; costellae unequal in size, those of the flanks finer than those in the middle, about 12 in 5 mm. at the margin.

Pedicle valve somewhat less deep than the brachial valve and with unevenly convex lateral profile, the posterior half fairly strongly convex, anterior half flattened. Anterior profile broadly but fairly gently convex; beak prominent; umbo somewhat narrowly rounded; median region moderately swollen; anterior half to third depressed into a broad, shallow sulcus; flanks bounding sulcus

gently swollen and with short and steep lateral and posterolateral slopes. Muscle scar narrowly rounded.

Brachial valve moderately convex in lateral profile, strongly convex and with short, steep slopes in anterior profile; sulcus shallow and narrow, originating at the umbo but indistinctly visible anterior to the middle; median and lateral areas strongly swollen. Notothyrial cavity narrow, supporting plates somewhat erect, median ridge wide, stout.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 14.0 | 12.7 | 15.9 | 10.8 | 9.4 |
| Paratype (110748) | 12.7 | 12.0 | 15.4 | 10.9 | 9.2 |
| " (110510b) | 12.4 | 11.8 | 14.5 | 11.2 | 9.1 |

Types.—Holotype: 110648a; figured paratypes: 110510a, 118006a; unfigured paratypes: 110510b, 110648, 110748, 118006b.

Horizon and locality.—Dryden formation in Tennessee: 1 mile west of Lone Mountain; Tazewell road, $1\frac{1}{2}$ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle. Evans Ferry section along U. S. Highway 25E, north of Indian Creek; $1\frac{1}{2}$ miles northeast of Halls School, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—This is a small, compact species occurring in the Wardell-Benbolt=Dryden formation of the belts near the Cumberland Front. It has the appearance of a small example of *D. gibbosus* but differs importantly from that species. In general the sulcus of the Tennessee species is shorter than that of the Minnesota form, and the brachial valve is deeper. This makes the Tennessee species somewhat thicker than the Minnesota one. This species differs from *D. regularis* in its narrower hinge and greater thickness as well as in its less uniform character.

DOLEROIDES MISSOURIENSIS Cooper, new species

Plate 94, B, figures 4-8

Shell fairly large, resembling *D. tennesseensis*; wider than long with a moderately wide hinge; sides rounded; anterior margin gently rounded; anterior commissure with a broad uniplicate wave; costellae unequal in size, the larger ones concentrated in the median region; costellae about 10 to 12 in 5 mm. at the front margin.

Pedicle valve unevenly convex, the posterior half moderately convex, the anterior half flattened. Anterior profile broadly but gently convex; posteromedian region and umbo swollen; sulcus originating slightly posterior to the middle, narrow, shallow, producing a small anterior tongue; flanks somewhat inflated but with steep posterolateral slopes. Interarea long, apsacline; muscle field large, somewhat oval in outline; adductor track narrow; dental plates prominent.

Brachial valve moderately convex in lateral profile; strongly convex in anterior profile; sulcus originating on umbo, shallow, narrow, extending to a point anterior to the middle; anteromedian region somewhat swollen but without forma-

tion of a distinct fold; flanks moderately swollen with moderately wide but steep slopes. Interior with short, stout brachioophores and strong, well-defined supporting plates. Median ridge short, narrow.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve)..... | 13.0 | ? | 16.0 | 12.9 | 5.0 |
| Paratype (" " 110582d)... | 13.1 | ? | 15.8 | 11.4 | 4.7 |
| " (brachial valve 110582n) .. | ? | 12.3 | 15.7 | 12.1 | 4.6 |

Types.—Holotypes: 110582b; figured paratypes: 110582a,d,n; unfigured paratypes: 110582c,e-m.

Horizon and locality.—Macy formation (Zell member) in Missouri: Along the old road 1 mile northwest of the Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E., Ste. Genevieve County.

Discussion.—This species is suggestive of *D. tennesseensis* but is somewhat more rounded than that species. It is also slightly more strongly costellate, has a narrower pedicle sulcus and somewhat less abrupt brachial wave in the anterior commissure.

DOLEROIDES OKLAHOMENSIS Cooper, new species

Plate 92, A, figures 1-4; plate 96, A, figures 1-21

Shell about medium size for the genus, wider than long with the hinge narrower than the greatest shell width which is located slightly anterior to the middle. Cardinal extremities obtuse, posterolateral margins straight, directed obliquely away from the midline; anterolateral extremities narrowly rounded, anterior margin gently rounded to nearly straight. Anterior commissure rectimarginate or faintly uniplicate or sulcate. Multicostellate, costellae unequal in size and appearing in about 4 generations and with a few scattered ones of larger size; about 17 in 5 mm. at the front margin. On the anterolateral extremities a tendency to fasciculation of the costellae is prominent. Costellae and interspaces marked by fine concentric fila.

Pedicle valve most convex in the posterior half when viewed in profile; anterior half somewhat flattened in the same view. Umbonal and median regions swollen and convex with moderately steep slopes to the cardinal extremities but less steep slopes to the lateral margins; anterior slope gentle. Interarea nearly procline, curved near the beak.

Brachial valve evenly and gently convex in lateral profile, broadly and gently convex in anterior profile. Sulcus originating at the umbo and extending as a narrow, shallow depression to the middle of the valve and from thence appearing as a wide, shallow or flattened space not affecting the anterior margin. Flanks bounding sulcus slightly swollen; umbonal slopes moderately steep. Interarea short, orthocline.

Pedicle interior with well-developed dental plates, elongate muscle field with long slender diductor scars; pallial trunks not well developed. Notothyrial cavity wide; cardinal process stout; brachioophores stout; brachioophore supports low and wide.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.0 | 10.6 | 13.5 | 9.6 | 6.6 |
| Paratype (110603b)..... | 11.8 | 11.4 | 13.8 | 7.0 | 7.8 |
| “ (110602a)..... | 10.9 | 10.3 | 13.6 | 10.0 | 6.3 |
| “ (110600a)..... | 12.0 | 11.3 | 14.5 | 11.0 | 7.0 |
| “ (110600b)..... | 12.0 | 11.4 | 14.1 | 11.2 | 7.0 |

Types.—Holotype: 110603a; figured paratypes: 110600a, 110602b, 110603b, 110613, 117033c,d,g,h; unfigured paratypes: 110600b, 110602a, 117033a,b,e,f.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: In the quarry on the east side of Oklahoma Highway 18, center NW $\frac{1}{4}$ sec. 11, T. 1 S., R. 3 E., 1.8 miles south of Sulphur, Murray County; Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Carter County; along U. S. Highway 77, SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County; Mountain Lake, E $\frac{1}{2}$ sec. 22, T. 2 S., R. 1 W., Carter County.

Discussion.—This species resembles *D. compressus* from the Mountain Lake member of the Bromide formation of Oklahoma but differs in its more elliptical outlines, more convex valves, and different ornamentation.

This species, like *D. compressus*, had a somewhat rounded outline and is a fairly small species. It is characterized by a rectimarginate commissure, a tendency toward production of a sulcus in both valves, thus producing an anterior emargination at the front. The species is most like *D. compressus* but differs in its more robust form and deeper valves. It differs from *D. pervetus* in not possessing a strong pedicle sulcus and in having different ornamentation.

DOLEROIDES OTTAWANUS Wilson

Doleroides pervetus ottawanus WILSON, Canadian Field-Nat., vol. 46, No. 6, p. 136, pl. 1, figs. 3-5; pl. 2, figs. 14, 15, 1932; Geol. Surv. Canada Bull. 8, p. 49, pl. 3, figs. 28, 29, 1946. *D. pervetus* COOPER, Journ. Paleont., vol. 4, No. 4, pl. 35, fig. 8, pl. 37, figs. 1, 3, 1930.

This species is described as intermediate in character between *D. gibbosus* and *D. pervetus*. It can be recognized by its wider form and less strongly folded commissure than in *D. gibbosus* and its larger size than that of *D. pervetus*.

Horizon and locality.—Black River (Leray=Chaumont), at many localities in the Ottawa and St. Lawrence Valleys.

Platteville formation in Wisconsin: At Highland, Iowa County.

DOLEROIDES PERVETUS (Conrad)

Orthis perveta CONRAD, Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 333, 1843; Pal. New York, vol. 1, p. 120, pl. 32, fig. 5, 1847.

Orthis (Dalmanella) subaequata var. *perveta* Conrad, WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, pl. 33, fig. 42 (only), 1893.

Doleroides pervetus (Conrad) COOPER, Journ. Paleont., vol. 4, No. 4, p. 381, pl. 36, figs. 4, 7, 1930.

Doleroides pervetus (Conrad) suggests a small edition of *D. gibbosus* which it precedes stratigraphically. The shell is small for the genus and suggests

D. irregularis. It differs from the latter in its wider hinge, less convex and shorter valves. Its small size and similarity to *D. gibbosus* will serve to identify the species in the Mississippi Valley.

Horizon and locality.—Platteville formation (McGregor member) in Rock County, Wis.: At Beloit and Janesville.

Same formation in Illinois: At Dixon, Lee County.

DOLEROIDES ? PONDEROSUS Cooper, new species

Plate 94, C, figures 9-18; plate 94, D, figures 19-21

Doleroides ? sp. Burrs, Virginia Geol. Surv. Bull. 52, pl. 80, figs. 22-24, pl. 81, figs. 34-35, 1942.

Subrectangular in outline, with the width greater than the length; lateral margins broadly rounded, anterior margin truncated; cardinal extremities obtuse; anterior commissure broadly uniplicate. Surface costellate, costellae narrowly rounded, elevated and with interspaces about equal in width to the costellae, 8 or 9 costellae in 5 mm. at the front margin, some standing out more prominently than others.

Pedicle valve in lateral profile most convex in the posterior half and flattened in the front half. Umbonal region convex, the convexity continued forward to a point not quite at the middle; posterolateral slopes long and steep. Sulcus broad and shallow, originating at about the middle and occupying slightly more than half the width at the anterior margin. Flanks flat in profile with moderately gentle slopes to the margins. Interarea short, curved, apsacline. Beak incurved.

Brachial valve moderately and evenly convex in lateral profile with the maximum curvature at about the middle; strongly and broadly convex in anterior profile. Umbonal region slightly convex, but anterior to the umbo and throughout the median part to the front margin, the shell is fairly strongly swollen and produces moderately steep slopes to the margins. Interarea short.

Pedicle interior with muscle area longer than wide and with narrow diductor impressions; thickened front margin with 2 short ridges anterior to it.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 26.6 | 24.7 | 32.6 | 26.8 | 15.8 |
| Paratype (110784) | 27.6 | 25.6 | 33.8 | 26.0 | ? |

Types.—Holotype: 98225b; figured paratypes: 98225c, 110774, 110778a, 110784; unfigured paratypes: 98225a, 110778b,c; figured specimens: 118003a,c.

Horizon and locality.—Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; lower part McNutt Quarry, 12 miles west of Bland, Burkes Garden (15') Quadrangle.

Botetourt formation in Virginia: At the junction of Virginia Highways 731 and 724, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Discussion.—This species is unlike any other member of the genus so far known in its large size and the alternating nature of the costellae. It was at first thought to be referable to *Mimella*, but the character of the pedicle muscle field

excludes it from that genus. The scar is smaller than usual in *Mimella*. The adductor scars are not elevated on a median callosity, but a low callus rim extends around the anterior margin of the field. Furthermore, a small ridge extends for a short distance anterior to the median point of the muscle field.

The undistorted types figured, although large specimens, are not the largest in the collections. A crushed individual from the locality northwest of Brownsburg measures 36.5 mm. long and 37.5 mm. wide. The specimen is somewhat lengthened and narrowed by the crushing, but in perfect condition the shell would nevertheless be larger than any other specimen known.

DOLEROIDES REGULARIS Cooper, new species

Plate 95, C, figures 21-28

Shell small to medium size for the genus, subrectangular in outline; hinge fairly wide but narrower than the midwidth; greatest width at about the middle; sides rounded; anterior commissure rounded; anterior commissure rectimarginate; costellae narrowly rounded with interspaces about equal to the costellae, about 11 in 5 mm. at the front margin; fasciculate along the margin, particularly on the flanks.

Pedicle valve about equal in depth to the brachial valve, moderately convex in lateral profile with the greatest convexity in the posterior half; anterior profile broadly convex; umbonal and median regions swollen, somewhat flattened anteriorly; lateral regions moderately convex and with long, gentle slopes to the margins. Apsacine; dental plates strong, bounding moderately deep umbonal cavities; muscle field elongate, diductor scars long; adductor track with a short anterior projection.

Brachial valve fairly strongly convex in lateral profile; broadly convex in anterior profile and with median region somewhat swollen; sulcus originating on the umbo, shallow and short, defined distinctly to the middle after which it merges somewhat with the swollen anterior half. Median and umbonal regions strongly swollen; lateral slopes steep and moderately long.

Measurements in mm.—Holotype, length 13.4, brachial length 12.9, width 16.9, hinge width 13.9, thickness 8.6.

Types.—Holotype: 118005a; figured paratypes: 110646a,f; unfigured paratypes: 110646b-e; figured specimen: 110592a.

Horizon and locality.—Wardell formation (top 40 feet) in Virginia: On Virginia Highway 610 at the southwest base of Paint Lick Mountain, Pounding Mill (15') Quadrangle.

Wardell formation in Tennessee: On the north side of the road 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle. On U. S. Highway 25E, $\frac{1}{2}$ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; Nicely and Palmer's store, $\frac{1}{2}$ mile east of Kate, Maynardville (30') Quadrangle.

Pierce formation in Tennessee: At Murfreesboro.

Dryden formation in Tennessee: Road along Little Sycamore Creek $\frac{1}{2}$ mile northeast of the west edge of Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—This species is characterized by medium size, fairly regular form, moderately strong costellae, rectimarginate anterior commissure, and moderately wide hinge. It differs from *D. irregularis* in its wider hinge and less convex valves. It suggests *D. extensus* but is not so strongly costellate and not so wide. This species differs from *D. tennesseensis* in having more nearly equally deep valves and a more regular outline.

DOLEROIDES TENNESSEENSIS Cooper, new species

Plate 93, C, figures 15-30; plate 94, A, figures 1-3

Shell of about medium size for the genus, wider than long, with the greatest width anterior to the middle. Hinge narrow; cardinal extremities obtusely angular; sides slightly rounded in the posterior half but narrowly rounded at the anterolateral extremities. Anterior commissure broadly uniplicate: Costellae of unequal size, some swollen and hollow, appearing in 4 generations by intercalation. The strongest costellae occupy the fold and sulcus where 2 narrow costellae may appear between the larger ones and extend for a considerable distance without expanding or swelling into normal size. From 10 to 12 costellae occupy a space of 5 mm. at the front margin of the fold and sulcus, while 14 to 16 costellae of various sizes may be counted in 5 mm. on the flanks. All costellae perforated by small scattered pits.

Pedicle valve moderately convex in lateral profile with the maximum convexity in the posterior half; anterior profile broadly and gently convex. Sulcus broad and shallow, usually originating near the middle and occupying from slightly less than one-half to one-third the width. Umbonal region convex, in some specimens distinguished as a low fold that may extend to about the middle and in some specimens may be continued anteriorly as a low rounding of the shell surface in the sulcus. Flanks gently convex with gentle lateral slopes but with steeper posterolateral slopes to the cardinal extremities which are deflected slightly toward the brachial valve. Interarea moderately long, curved, apsacline. Beak pointed and incurved.

Brachial valve moderately and evenly convex in lateral profile with the greatest convexity at about the middle; anterior profile moderately and somewhat narrowly convex with the top of the curve flattened and the sides flat but descending with fairly steep slopes. Umbonal region marked by a narrow and shallow sulcus which may extend to the front margin or disappear near the middle. Sulcus impressed in a broad and poorly defined fold that is most pronounced in the anterior half of the valve and is best seen on the anterior commissure. Flanks flattened and with moderately steep slopes to the margins. Interarea short, apsacline.

Interior: Pedicle muscle field elongate-oval in outline, not greatly widened anteriorly with long and slender diductor impressions and a slightly elevated adductor field. Adjustor impressions narrow. Dental plates short with shallow umbonal cavities. Pallial impressions not preserved.

Brachial interior with moderately wide notothyrial cavity, moderately thick brachioophores and supporting plates; cardinal process slender; median ridge low, fairly slender.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 13.8 | 13.0 | 17.7 | 13.9 | 8.9 |
| Paratype (110635a) | 14.5 | 13.7 | 18.3 | 12.0 | 9.8 |
| " (110635e) | 15.9 | 14.8 | 19.8 | 12.3 | 10.4 |

Types.—Holotype: 117034a; figured paratypes: 110628, 110635a,f, 110639e,i; unfigured paratypes: 110635b-e,g-l, 110639a-d,f,h; figured specimens: 118002a-c.

Horizon and locality.—Upper half of Lebanon formation in Tennessee: Beside U. S. Highway 41, $\frac{3}{4}$ mile south of Knox Branch, 9 miles southeast of Murfreesboro; Columbia; 3 miles east of Murfreesboro; opposite Fairview Service Station on U. S. Highway 70N, 11.6 miles east of Lebanon city limit, 2.5 miles east of Wilson-Smith County line on U. S. Highway 70N; at east end bridge over Round Lick Creek, Rome; 20 feet above *Cryptophragmus* on south side U. S. Highway 70S, $\frac{1}{2}$ mile east of Readyville.

Cane Creek formation (95 feet above base) in Virginia: North of Chattels Station Church, on old U. S. Highway 58, 2 miles west-southwest of Ewing, Ewing (T.V.A. 161-NW) Quadrangle.

Carters formation in Alabama: At quarry $\frac{1}{2}$ mile north of Gate City on Red Mountain; Clifton Terrace, Birmingham, Leeds (15') Quadrangle.

Discussion.—This species is characterized by its fine costellae, deep valves, broadly uniplicate anterior commissure, and moderately wide hinge. This species is readily separated from such other Tennessee species as *D. crassus* and *D. extensus* by its finer costellae. It differs from both Oklahoma species in its larger size and more robust form. It is larger than *D. pervetus* and differently folded. It is more finely costellate than the other Upper Mississippi Valley species. Its closest relative is *D. missouriensis* from the Macy formation. It differs from that species in lesser width, a stronger brachial sulcus, wider pedicle sulcus, and broader plicate wave in the brachial valve. *Doleroides tennesseensis* is more finely costellate, somewhat wider, and with less prominent brachial sulcus than *D. ottawanus* Wilson.

DOLEROIDES WINCHELLI Cooper, new name

Plate 93, A, figures 1-7

Orthis media N. H. WINCHELL (not Shaler, 1865), 8th Ann. Rep. Minnesota Geol. Nat. Hist. Surv., p. 64, 1880.

Large for the genus, wider than long and subrectangular in outline; sides rounded; anterior margin nearly straight; anterior commissure strongly uniplicate; costellae strong, those on the fold and sulcus slightly stronger than those of the flanks; about 8 costellae in 5 mm. in the median region and about 10 in 5 mm. at the flanks, both counts taken at the anterior margin.

Pedicle valve with unevenly convex lateral profile, the posterior half moder-

ately convex but the anterior half somewhat flattened. Anterior profile almost flat to broadly and gently convex; umbonal region swollen, sulcus originating at about the middle, broad and shallow at its origin but widening and deepening to the anterior margin where it occupies nearly half the width; flanks bounding sulcus gently convex; posterolateral extremities narrowly convex and with steep slopes, and strongly deflected toward the brachial valve. Interarea long, curved, apsacline. Muscle field long with subparallel sides; adductor track wide at front; diductor scars long and narrow.

Brachial valve deeper than the pedicle valve, gently convex in lateral profile, strongly convex in anterior profile. Fold originating at about middle, low and wide and only moderately elevated; flanks gently convex; posterolateral extremities gently sulcate; lateral slopes steep.

Measurements in mm.—Hypotype (110578a), length 17.0, brachial length 15.3, width 20.8, hinge width 15.8, thickness 10.0.

Types.—Figured hypotypes: 110578a,b.

Horizon and locality.—Decorah formation (Spechts Ferry member) in Minnesota: At Fountain, Fillmore County.

Same formation in Wisconsin: At Highland, Iowa County; 2 miles west of Platteville, Grant County.

Discussion.—This species is characterized by its large size, wide hinge, prominent and somewhat elevated fold, and strongly uniplicate anterior commissure. It differs from *D. gibbosus* with which it has been confused in the character of the brachial fold and the abbreviation of the brachial sulcus. In *D. winchelli* the sulcus on the brachial valve is narrow and shallow and extends anteriorly to about the middle. It is also independent of the fold on which it occurs. In *D. gibbosus*, on the other hand, the fold is rather a broad but strong wave of the anterior commissure, but the sulcus originates at the beak, is shallow, extends anteriorly, widening in the same direction to the anterior margin, where, however, it does not affect the commissure. The pedicle sulcus is also more pronounced in *D. winchelli* than in *D. gibbosus*. The name *Orthis media* was preoccupied, therefore the name *D. winchelli* is proposed.

DOLEROIDES sp. 1

Plate 95, D, figures 29, 30

Shell large for the genus, subrectangular in outline, wider than long; costellae fairly even, 10 to 11 in the space of 5 mm. at the anterior margin; costellae with fine scattered pits on surface.

Pedicle valve with swollen umbo and median region; sulcus occupying anterior third, shallow but wide; flanks gently convex; interarea long, apsacline. Muscle field small, narrowly elliptical in outline.

Brachial valve moderately convex in lateral profile; strongly convex in anterior profile; sulcus scarcely defined, not reaching the margin; median and lateral regions swollen; lateral slopes short and steep.

Measurements in mm.—Pedicle valve, length 14.7, width 18.9.

Figured specimens.—118004a,b.

Horizon and locality.—Pierce formation in Tennessee: At Pierce Mill, on Tennessee Highway 10, just south of Walterhill, $7\frac{1}{2}$ miles north-northeast of Murfreesboro, Rutherford County.

Genus **MIMELLA** Cooper, 1930

Mimella COOPER, JOURN. PALEONT., vol. 4, No. 4, p. 375, 1930.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 61, 1932.

Mimella can be recognized by its generally hebertelloid outline, but its pedicle valve is usually more convex than that of *Hebertella*. The pedicle muscle scar of *Mimella* is the most important and diagnostic feature of the genus. This is characterized by subparallel or divergent, elongate and deeply sunk diductor tracks separated by an elongate and usually anteriorly expanded and elevated adductor track. The brachial interior is like that of the rest of the hebertelloids.

Small distinctions are possible between Marmor and post-Marmor *Mimellas*. The earliest forms generally are rectimarginate, but they also have a fairly strongly pronounced sulcus in the umbonal and median regions. Generally the sulcus does not reach the anterior margin. Post-Marmor *Mimellas* are often umbonally sulcate, but the anterior commissure is usually broadly uniplicate. The folding of the anterior commissure is usually confined to the marginal region of the valves because no species is known with a strong and pronounced median fold on the brachial valve. These features are of some help in sorting the species stratigraphically.

A note on the genotype of the species is important. When the genus was established, Cooper cited *Pionodema globosa* Willard as the type species. Willard also described *Hebertella melonica* which belongs to the genus *Mimella*. The results of the present studies indicate that these two species are the same. It seems best, therefore, to put *H. melonica* in the synonymy of *M. globosa* because the latter species was selected as the type of the genus.

Mimella, according to present studies, appears first in the middle of the Chazyan (Crown Point) and extends into the Wardell formation. The genus is abundant in the Benbolt formation where it attains a large size. *Doleroides* appears first in the Dryden formation and becomes fairly common in Wardell rocks. In still higher rocks of the lower Trentonian, *Doleroides* is the abundant hebertelloid.

MIMELLA BICONVEXA Cooper, new species

Plate 87, C, figures 16-19

Large, wider than long, transversely elliptical in outline; hinge narrower than the greatest width which is at about the middle. Cardinal extremities obtuse. Anterior commissure gently uniplicate. Surface covered by nearly uniform, fine costellae about 14 in 5 mm. at the front. Costellae exopunctate.

Pedicle valve with lateral profile fairly evenly convex with the maximum convexity near the middle. Sulcus originating at about the middle, narrow and

shallow and producing a small tongue. Flanks slightly convex with fairly steep posterolateral slopes and moderately steep anterior and lateral slopes. Interarea short, curved, apsacline. Delthyrium narrow.

Brachial valve strongly convex in lateral profile with the maximum convexity at about the middle. Anterior profile also strongly convex, this valve having greater depth than the pedicle one. Fold visible only as a wave of the anterior margin in the brachial direction. Median region inflated, with steep slopes to all the margins. Umbonal region somewhat inflated. Interarea short and slightly apsacline.

Interior of the pedicle valve with a broadly triangular muscle field having a wide adductor track.

Measurements in mm.—Holotype, length 18.6, brachial length 18.2, width 27.0, hinge width 19.0, thickness 16.6.

Types.—Holotype: 48755a; figured paratype: 110652a.

Horizon and locality.—Pierce and Ridley formations in Tennessee: At Murfreesboro.

Discussion.—This species attains a large size and is characterized by its inflated valves, gentle contours, and fine costellae. It is a rare species, at present known from the Pierce and Ridley (?) limestones of the Central Basin of Tennessee. In size this species suggests *M. globosa*, but it is actually smaller than the largest of that species. Furthermore, the exterior contours and profiles are quite different, the East Tennessee species being much less inflated.

MIMELLA BOREALIS (Billings)

Plate 85, E, figures 38, 39

Orthis borealis BILLINGS, Canadian Nat. Geol., vol. 4, p. 436, fig. 14, 1859.—LESLEY, Geol.

Surv. Pennsylvania, Rep. P 4, p. 510, figs., 1889.

Hebertella borealis (Billings) RAYMOND, Ann. Carnegie Mus., vol. 7, p. 241, figs. 13, 14, 1911.

Types.—Holotype: G.S.C. 1035c.

Horizon and locality.—St. Martin formation in Quebec Province, Canada: Caughnawaga, La Prairie County.

MIMELLA COSTELLATA Cooper, new species

Plate 91, A, figures 1-7a

Shell small for the genus, subelliptical to subrectangular in outline; sides rounded, anterior margin subtruncate. Hinge narrower than the greatest shell width which is at about the middle. Anterior commissure broadly uniplicate; lateral commissure deflected toward the brachial valve near the cardinal extremities. Surface evenly and finely costellate, 20 costellae in a space of 5 mm. at the front margin.

Pedicle valve strongly convex in posterior half but flattened anteriorly when seen in lateral profile. Anterior profile moderately convex with the greatest convexity in the median portion. Umbonal region strongly convex. Sulcus shallow and narrow, not conspicuous and originating near the middle. Flanks flattened

to slightly concave and with gentle anterior slopes but moderately steep posterolateral slopes. Interarea strongly curved, apsacline. Beak prominent and incurved.

Brachial valve about equal in depth to the pedicle one, with a fairly strongly convex lateral profile with the posterior half swollen. Anterior profile strongly convex and with steep lateral slopes. Fold imperceptible; the entire median region somewhat swollen with an inflated umbo and steep posterolateral and lateral slopes. Anterolateral slopes moderately steep. Interarea curved, apsacline.

Measurements in mm.—Holotype, length 11.6, brachial length 11.0, width 14.7, hinge width 10.5, thickness 8.1.

Types.—Holotype: 110658a; figured paratype: 110658b.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 1 mile southeast of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; Inskip, Fountain City (T.V.A. 146-SW) Quadrangle; Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species is characterized by its generally small size and its finely costellate exterior. It differs from *M. similis*, also occurring in the Hogskin shale, by its more swollen valves, particularly the pedicle valve, and its finer ornamentation.

MIMELLA EXTENSA Cooper, new species

Plate 86, A, figures 1-21; plate 90, A, figures 1-15

Shell of about medium size for the genus; wider than long; hinge not equal to the greatest shell width which is at about the middle, but unusually wide nevertheless. Cardinal extremities obtuse to acute, frequently with pointed ears. Lateral margins gently rounded; anterior margin broadly rounded; anterior commissure broadly uniplicate. Surface costellate, 8 to 10 costellae in the space of 5 mm. at the front margin; costellae narrowly rounded and somewhat elevated with interspaces about equal to the width of the costellae; costellae marked by innumerable small pores or exopunctae with elevated rims.

Pedicle valve moderately convex in outline with the greatest curvature located in the posterior third; umbonal region gently convex; beak erect; sulcus originating near the middle, poorly defined and very shallow. Flanks slightly convex and the slopes to the cardinal extremities and lateral margins gentle. Interarea long, nearly procline along the cardinal margin but curving to an apsacline position near the beak.

Brachial valve fairly strongly convex in lateral profile, with the maximum curvature near the middle; strongly convex in anterior profile but with the shell near the margins slightly flattened. Sulcus originating on the umbo and extending beyond the middle of the valve as a shallow and narrow depression disappearing near the front. Fold visible only as a wave in the anterior commissure toward the brachial valve. Median portion of valve swollen and with steep slopes to the cardinal extremities but more gentle slopes to the anterolateral and anterior margins.

Pedicle interior with small teeth having deep fossettes. Muscle field large but

variable, strongly elevated at its front margin. Brachial interior typical for the genus and family.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 15.2 | 15.5 | 18.9 | 16.5 | 11.6 |
| Paratype (pedicle valve 110662a) .. | 20.7 | ? | 25.3 | 23.0 | 6.1 |
| " (117037j) | 11.3 | 11.7 | 15.1 | 13.8 | 7.7 |
| " (brachial valve 110669b) .. | ? | 20.1 | 25.1 | 22.5 | 6.3 |

Types.—Holotype: 117037c; figured paratypes: 110662a, 110669b, 117037a-f, h-j; unfigured paratypes: 110662b,c, 110669a,c-i, 117037g; figured specimen: 110663.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: On Oklahoma Highway 99, zone 36, SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, T. 1 N., R. 6 E., 3 miles south of Fittstown, Pontotoc County; Decker's zone 5, sec. 14a, about 2 miles southeast of McLish Ranch, near Bromide, Johnston County; *Mimella*-bryozoan bed, 2,300 feet south and 2,000 feet west of the northeast corner sec. 36, T. 1 S., R. 7 E., Johnston County; Decker's bed 16, on West Branch of Sycamore Creek, sec. 22 and 27, T. 3 S., R. 4 E., Johnston County; top of bed 13, old road on hill northwest of old Galbraith Hotel, sec. 32, T. 1 S., R. 8 E., Johnston County; Rock Crossing of Hickory Creek, approximately center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County; along creek 1 $\frac{1}{4}$ miles west and $\frac{3}{4}$ mile south of Nebo, SE $\frac{1}{4}$ sec. 27, R. 2 S., T. 3 E., Murray County; road cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; 30 feet above the Bromide sand in Spring Creek section, sec. 17, T. 2 S., R. 1 W., Murray County; bed 17, 266 feet below the top, sec. 22, T. 2 S., R. 3 E., 1 $\frac{1}{2}$ miles west of Nebo, Murray County; *Mimella* zone, Baptist Grounds on Falls Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 1 S., R. 2 E., Murray County; bed 22, road cut center N $\frac{1}{4}$ sec. 11, T. 2 S., R. 3 E., Murray County.

Discussion.—This species is fairly common in the Mountain Lake member of the Bromide formation at a few localities. It is characterized by a moderately transverse form and a wide hinge which produces in many instances small ears or prominent cardinal extremities. The species as identified herein is variable and like other members of the genus includes narrow as well as wide forms. The wide-hinged forms are not like any species known from the Appalachian Valley region. They are also unlike any other Oklahoma species. The narrow forms which resemble *M. subquadrata* in outline and profile are more finely costellate.

MIMELLA GILBERTI Cooper, new species

Plate 128, A, figures 1-5

Shell of about medium size for the genus, wider than long, hinge narrower than the maximum shell width which is located anterior to the middle; sides oblique, anterolateral extremities narrowly rounded; anterior margin broadly rounded; anterior commissure fairly strongly uniplicate. Surface finely costate, about 46 costae along the front margin.

Pedicle valve unevenly convex in lateral profile, the maximum convexity just anterior to the umbo and the anterior two-thirds flattened; anterior profile broadly but gently convex. Umbonal region gently swollen; sulcus broad and shallow, originating at about the middle and deepening to the anterior margin; flanks bounding sulcus somewhat flattened. Posterolateral extremities deflected toward the brachial valve and steep. Interarea long and steeply apsacline.

Brachial valve fairly evenly and strongly convex in lateral profile; anterior profile strongly domed; umbonal and median region swollen, the swelling continuing to the anterior margin to form an ill-defined fold; sides gently convex and with steep slopes to the margins.

Measurements in mm.—Holotype, length 14.3, brachial length 14.1, midwidth 17.0, hinge width 11.8, thickness 10.5.

Types.—Holotype: 123288a; unfigured paratype: 123288b.

Horizon and locality.—Ellett formation (40 to 100 feet above the Knox dolomite) in Virginia: On the west side of the road, 2 miles south of Lusters Gate, Blacksburg (15') Quadrangle.

Discussion.—This species is characterized by its fairly large size for such a stratigraphically low *Mimella*. It is suggestive of *M. nuclea* but is a much larger species with a much more prominent fold and sulcus. *M. nuclea* has only a slight development of these features. This is true also of *M. vulgaris* which approaches the Virginia species in size. The latter is also different in outline from the Virginia species. *M. valcourensis* and *M. transversus* approach *M. gilberti* in size but are much more finely ornamented.

MIMELLA GLOBOSA (Willard)

Plate 37, A, figures 1-4; plate 88, A, figures 1-30; plate 89, A, figures 1-14

Pionodema globosa WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 274, pl. 2, fig. 5, 1928.

Hebertella melonica WILLARD, *ibid.*, p. 263, pl. 1, figs. 8, 9, 1928.

Mimella superba BUTTS, Virginia Geol. Surv. Bull. 52, p. 93, pl. 90, figs. 33-36, 1942.

Shell large for the genus, wider than long with the greatest width at about the middle; hinge narrow; cardinal extremities obtuse. Sides and anterolateral extremities broadly rounded; anterior margin nearly straight; anterior commissure rectimarginate to faintly uniplicate. Costellae fine, about 10 to 13 in 5 mm. at the front margin of a large adult.

Pedicle valve moderately convex in lateral profile with the maximum convexity in the median region; anterior profile gently and broadly convex; umbo swollen; median region and anterior half flattened to faintly sulcate; lateral areas gently convex; posterolateral slopes long, moderately steep. Interarea moderately long, apsacline: Muscle field heart shaped, deeply impressed, and with a thickened anterior rim; adductor track wide; pallial impressions commonly exquisitely preserved.

Brachial valve strongly convex in lateral profile and with the greatest convexity slightly posterior to the middle; anterior profile strongly convex with the median region somewhat narrowly rounded; umbo swollen, sulcus narrow,

shallow, extending from umbo to anterior margin; flanks bounding sulcus swollen; lateral and posterolateral slopes long and steep. Notothyrial cavity of moderate size; brachioophore plates somewhat reclining; median ridge short; pallial marks fairly well impressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---|--------|-----------------|-------|-------------|-----------|
| Holotype | 18.8 | 18.7 | 21.4 | 15.2 | 11.0 |
| Hypotype (117040a) | 25.5 | 24.3 | 30.4 | 24.4 | 15.5 |
| " (110686b) | 22.9 | 21.5 | 24.9 | 18.8 | 17.3 |
| " (110718) | 18.2 | 18.2 | 20.0 | 15.6 | 10.9 |
| " (117038a) | 19.0 | 18.6 | 23.5 | 21.0 | 12.1 |
| Holotype (<i>M. melonica</i> M.C.Z. 8596) .. | 25.4 | 25.7 | 29.9 | 21.0 | 15.5 |

Types.—Holotype: M.C.Z. 8609; figured hypotypes: 110680, 110686a,b, 110713a, 110715, 110718, 110752, 117038b, 117040c,d,f,i, 117041a,b, 117042b; unfigured hypotypes: 117038a, 117040a. Holotype *Mimella melonica* (Willard): M.C.Z. 8596; holotype *M. superba* Butts: U.S.N.M. 98210.

Horizon and locality.—Benbolt formation in Virginia: West slope of the hill $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle; south side of Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; roadside $\frac{1}{4}$ mile southwest of New Bethel Church, Hilton (T.V.A. 197-NW) Quadrangle; $\frac{1}{2}$ mile northeast of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; Fugates Hill, 2 miles N. 45° W. of Mendota, Bristol (30') Quadrangle; Lake View Church on Virginia Highway 71, Russell County; Virginia State Highway 80, $\frac{1}{2}$ mile south of Rockdell, Elk Garden (T.V.A. 212-NW) Quadrangle; on the road to Hansonville, 4 miles northeast of Gate City, Gate City (T.V.A. 188-NE) Quadrangle.

Benbolt formation Tennessee: 0.1 to 0.2 mile north of the road 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Ridley formation in Georgia: On U. S. Highway 27, just northwest of Chickamauga Creek, Kensington (T.V.A. 106-SE) Quadrangle.

Dryden formation in Tennessee: Lone Mountain to Tazewell road, $1\frac{1}{2}$ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; hillside south of Dutch, Dutch Valley (T.V.A. 154-SE) Quadrangle; 2 miles northeast of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle; Sycamore Creek, northwest corner Maynardville (T.V.A. 145-SE) Quadrangle; south side of the road 1 mile northeast of the watergap south of Bray, Morristown (30') Quadrangle.

Dryden formation (Benbolt part) in Virginia: Several localities at Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is characterized by its large size, actually approaching that of *M. imperator* but never equalling it. *Mimella globosa* is further featured by its nearly rectimarginate anterior commissure. The commissure when folded has a broad and gentle wave in the direction of the brachial valve. This character is like that of the Chazyan *Mimellas*, but they are generally with stronger ornamentation than any of the Benbolt forms. The brachial valve of

M. globosa is often gently sulcate in the posterior half, but the sulcus disappears before the anterior margin is reached. This is unlike *M. imperator* which has a stronger and more prominent sulcus.

The large size of *M. globosa* restricts its comparison to a few species only. It differs from *M. biconvexa* in its more quadrate form and less inflated pedicle valve. It differs from *M. sulcata* in its lack of brachial folding and less inflated pedicle valve.

The species as here conceived includes a number of specimens that seem clearly to be obese forms that thickened and widened but did not extend the hinge normally. Some of these occur with more normal members of the population, but one locality near New Bethel Church, Hilton (T.V.A. 197-NW) Quadrangle, produce a majority of obese forms. The ornamentation of the thickened specimens is like that of the normal shells. For these reasons the specimens are referred to *M. globosa*.

It is important to state why the writer as first reviser of these species has used the specific name *M. globosa* which has page priority and is based on an adult specimen with pedicle interior. The species *Pionodema globosa* Willard, which proved not to belong to the genus to which it was originally assigned, was selected by Cooper (1930) as the type of the genus *Mimella*. It will therefore cause little confusion to place *H. melonica* as a synonym of *M. globosa* rather than the other way around. *Mimella superba* of Butts is also placed in synonymy with *M. globosa*. The type specimen of that species externally is like *M. melonica* but is somewhat more strongly ribbed. It is not, however, more strongly ribbed than variants of the population which often lived together.

MIMELLA GLOBULARIS Cooper, new species

Plate 87, E, figures 25-37

Shell of about medium size for the genus, wider than long; subrectangular in outline; strongly biconvex with the brachial valve having a slightly greater depth than the pedicle one. Anterior commissure broadly uniplicate; sides somewhat narrowly rounded. Hinge narrower than the greatest shell width; cardinal extremities obtusely angular. Costellate; costellae subequal in size, crowded and separated by striae of less width than the costellae. About 17 costellae in the space of 5 mm. at the front.

Pedicle valve moderately convex in lateral profile with the greatest convexity located in the posterior half, the anterior half somewhat flattened. Anterior profile broadly convex. Sulcus nearly obsolete, the only trace shown is a broad flattening in the anteromedian third of the valve. Posterolateral slopes very steep but becoming more gentle anteriorly. Anterolateral and anterior slopes gentle. Beak erect and prominent, only slightly incurved; interarea long, apsacline.

Brachial valve strongly convex in lateral profile; broadly convex in anterior profile. Umbo marked by a shallow and narrow depression that extends from the beak nearly to the middle of the valve. Fold obsolete, but a broad wave of

the anterior margin in a brachial direction serves as a fold. Median area swollen, slopes in all directions from median area steep, but the lateral and posterolateral slopes are the steepest.

Pedicle interior with subpentagonal muscle area having long, narrow diduc-tor scars and a broad adductor field. Median ridge of brachial valve extending about to middle. Notothyrial cavity deep, brachioophore supports strong.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve)..... | 13.3 | ? | 14.5 | 11.4 | 4.1 |
| Paratype (" " 110687g)... | 11.4 | ? | 12.8 | 10.7 | 4.5 |
| " (brachial valve 110687b) .. | ? | 13.0 | 17.1 | 12.9 | 6.0 |
| " (" " 110687i) .. | ? | 12.0 | 14.5 | 11.8 | 5.6 |
| " (" " 110687a) .. | ? | 11.8 | 14.6 | 11.9 | 5.3 |

Types.—Holotype: 110687d; figured paratypes: 110687a,c,f,g,i; unfigured paratypes: 110687b,e,h.

Horizon and locality.—Yellow Branch member of Poteet formation in Virginia: On the road beside Yellow Branch (Creek) 5 miles southeast of Rose Hill, Rose Hill (T.V.A. 161-NE) Quadrangle.

Ridley formation in Tennessee: 7 miles southwest of Pikeville, Sequatchie Valley, Bledsoe County.

Discussion.—This is a rare species best known from near Rose Hill where it is common in a silicified state in a calcarenite in the lower part of the section. The species is characterized by its medium size, rotund and swollen form, and fine ornamentation. Its outline is similar to that of *M. intermedia*, but its valves, particularly the pedicle valve, are much more swollen and its ornamentation more delicate. It is suggestive of *M. similis* and *M. costellata* in its fine ornamentation but differs from both in the shape and more swollen valves.

MIMELLA IMPERATOR (Billings)

Plate 85, F, figures 40-45

Orthis imperator BILLINGS, Canadian Nat. Geol., vol. 4, p. 435, figs. 11-13, 1859; Geol. Canada, p. 129, fig. 55, 1863.—LESLEY, Geol. Surv. Pennsylvania, Rep. P 4, p. 518, figs., 1889.

Hebertella imperator (Billings) HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 222, 1892.—RAYMOND, Ann. Carnegie Mus., vol. 7, p. 243, pl. 36, figs. 6, 7, 1911.—WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 26, sec. 4, p. 381, pl. 2, figs. 1, 2, 1932.

Types.—Syntypes: G.S.C. 1036, a; figured hypotypes: Carnegie Mus. 5447, 5448.

Horizon and locality.—Aylmer formation (Rockcliffe member) in Ontario, Canada: 4½ miles west of Ottawa; Hawkesbury. Same formation in Quebec, Canada: At Aylmer.

Discussion.—This is the largest of the known species of the genus. This is an anomalous fact because the species shows primitive features in its fairly strong brachial sulcus and faintly medially folded pedicle valve. Well-preserved but partially exfoliated specimens (G.S.C. 1036, a) in the Geological Museum of

Canada show the characteristic *Mimella* pedicle muscle scars and some details of the pallial marks. In the pedicle valve the ovarian impressions are small but prominent and marked by oblique wavy lines. The pallial trunks are separated by shallow depressions. In the brachial valve the main trunks are given off from the anterior ends of the adductors and branch anteriorly.

MIMELLA INTERMEDIA Cooper, new species

Plate 90, B, figures 16-20; plate 91, E, figure 25; plate 91, F, figures 26-28;
plate 91, I, figures 37-39

About medium in size for the genus, slightly wider than long with the greatest width at or slightly anterior to the middle; cardinal extremities obtusely angular; sides slightly sinuate just anterior to the cardinal extremity; anterolateral extremities narrowly rounded; anterior margin truncated to emarginate; anterior commissure rectimarginate. Costellae numbering 9 to 11 in 5 mm. at the anterior margin, separated by striae narrower than the costellae.

Pedicle valve gently convex in lateral profile, the greatest convexity in the umbonal region and the anterior half or more somewhat flattened. Anterior profile broadly and gently convex but with short, steep lateral slopes. Beak somewhat elongated; umbo swollen; median half occupied by a narrow, shallow sulcus which disappears at the margin. Flanks bounding sulcus gently swollen; posterolateral slopes short and steep. Interarea approximately procline, slightly curved but with the beak abruptly curved. Interior with large, heart-shaped muscle area; adductor track wide and anteriorly elevated; pallial marks not preserved.

Brachial valve strongly convex, with the greatest curvature in the umbonal region; anterior half moderately convex; anterior profile strongly convex with long and steep lateral slopes; umbo sulcate; umbo strongly swollen; median part of anterior and middle flattened to faintly sulcate; flanks bounding median region moderately swollen; posterolateral slopes steep; cardinal extremities deflected to form small ears. Interior with thin cardinal process; notothyrial cavity moderately deep, median ridge narrow, not reaching to the middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 15.2 | 15.2 | 17.6 | 14.8 | 12.0 |
| Paratype (117044a) | 16.2 | 16.0 | 17.4 | 13.5 | 13.1 |

Types.—Holotype: 117044b; figured paratypes: 110703a,b, 117043, 117998; unfigured paratype: 117044a.

Horizon and locality.—Whistle Creek formation in Virginia: On Whistle Creek, $1\frac{1}{2}$ miles northwest of Lexington; on U. S. Highway 60 about 100 yards southeast of Whistle Creek, 2 miles northwest of Lexington, Lexington (15') Quadrangle; $3\frac{1}{2}$ miles southwest of Bolton, Bristol (30') Quadrangle.

Elway formation in Tennessee: Along the road over Marble Bluff just north of summit about 8 miles west-northwest of Loudon, Loudon (30') Quadrangle;

on U. S. Highway 25W, 4.7 miles south of Clinton, Powell Station (T.V.A. 137-SE) Quadrangle.

Discussion.—*Mimella intermedia* is characterized by a subquadrate form, nearly rectimarginate anterior commissure, fairly strongly convex valves and fairly strong ornamentation. The species resembles *M. subquadrata* but differs in having somewhat finer costellae, more erect and elongate pedicle beak, somewhat narrower hinge, and less prominently waved anterior commissure.

This species might be confused with some of the stratigraphically younger narrow forms of *M. globosa*. The latter are generally thicker shelled and give evidence of obesity rather than normal specific characters. These obese forms also generally have much more swollen valves than the normal Elway and Whistle Creek species.

MIMELLA LATICARDINIA Cooper, new species

Plate 90, C, figures 21-34

Shell of about medium size for the genus, slightly wider than long; greatest shell width at about the middle; sides broadly rounded, anterior margin broadly rounded. Anterior commissure gently uniplicate. Surface costellate, with 9 costellae occupying a space of 5 mm. at the front margin of a full-grown specimen. Costellae appear in 3 or 4 generations.

Pedicle valve most convex in the posterior third when viewed in lateral profile; posterior third moderately convex but anterior two-thirds flattened. Umbonal region gently convex with erect beak; sulcus originating 10 to 12 mm. anterior to the beak, poorly defined in medium-sized shells, more strongly defined in fully grown specimens but in any case seldom deep. Posterior half slightly swollen, the fullness continued on each side of the median depression to the anterior margin; lateral slopes moderately steep. Interarea long, slightly curved, apsacline.

Brachial valve with the maximum convexity at about the middle in lateral profile. Anterior profile strongly convex in the middle but lateral slopes only moderately steep. Umbo marked by a short (6 or 7 mm.), narrow sulcus changing anteriorly into a barely perceptible fold. Median region and posterior swollen, with steep slopes to the cardinal extremities and lateral margins. Anterior slope gentle. Interarea short, curved, apsacline.

Pedicle interior with small teeth having deep fossettes; dental plates strong, bowed outward near the junction with the floor of the valve and continued anteriorly along the margins of the muscle field as a low ridge. Adductor track long and wide at the front; diductor impressions narrower than the adductor track; pallial marks not strongly impressed.

Brachial valve with short brachioophores, moderately strong median ridge, and brachioophore supports resting on the floor of the valve; cardinal process slender.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 19.4 | 18.0 | 21.8 | 18.0 | 12.7 |
| Paratype (110709b) | 14.8 | 14.4 | 17.0 | 13.3 | 9.8 |
| " (110706b) | 17.5 | 16.6 | 20.6 | 16.4 | 11.0 |

Types.—Holotype: 110709a; figured paratypes: 110700a-d, 110702a, 110706b; unfigured paratypes: 110700e, 110702b-f, 110706a, 110709b.

Horizon and locality.—Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile northwest of Eidson Post Office, Kyles Ford (T.V.A. 170-SE) Quadrangle; Evans Ferry section, northeast of Indian Creek on U. S. Highway 25E, Howard Quarter (T.V.A. 162-NW) Quadrangle; on U. S. Highway 25E, Thorn Hill section, shale unit south of first bridge north of Thorn Hill Post Office, Avondale (T.V.A. 162-SW) Quadrangle.

Lincolnshire formation in Virginia: In Marcem Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle; Virginia Highway 19, 0.3 mile east-southeast of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; at spring $\frac{1}{4}$ mile east of junction of Virginia Highways 608 and 652, 6 miles south-east of Staunton, Augusta County; north side of Moccasin Creek, 0.2 mile west of New Bethel Church, Hilton (T.V.A. 197-NW) Quadrangle.

Murat formation (calcarenite facies of Lincolnshire) in Virginia: 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This is not a common species as far as the author's collecting experience in the Appalachians indicates. It was common in the shaly beds of the Lincolnshire formation north of Eidson, but that place is now fairly well exhausted. The species, as usual with *Mimella*, is somewhat variable in all its features. Generally it is rectangular in outline with a fairly wide hinge, moderately inflated valves, usually moderately uniplicate anterior commissure, prominent beak, and moderately strong costellae.

This is one of the largest of the *Mimella* species below the Benbolt and, inasmuch as it occurs in some shaly beds, it may be confused with *M. globosa*. It, however, seldom attains the large size of that species and usually has more pronounced anterior folding and finer costellae than the Benbolt form. The Lincolnshire species differs from *M. intermedia* in its more transverse outline. It differs from *M. tumida* of the Hogskin member in its generally smaller size, finer ornamentation, and more quadrate form.

Specimens from the Lincolnshire formation at Marcem Quarry west of Gate City have been placed here, although they are larger and with somewhat more inflated pedicle valve than *M. laticardinia*, but medium-sized specimens from the same place are very close to the Eidson forms.

MIMELLA LATISTRIATA (Wilson)

Hebertella latistriata WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 26, sec. 4, p. 380, pl. 2, figs. 4-7, 1932.

Types.—Holotype: G.S.C. 6524; paratypes: G.S.C. 6524a, 6525.

Horizon and locality.—Aylmer formation in Ontario, Canada: From the shaft at the west end of Barnhart Island southwest of Cornwall.

MIMELLA MINGANENSIS Twenhofel and Whiting

Orthis piger BILLINGS, (part), Canadian Nat., vol. 4, pp. 442-443, 1859.

Mimella ? *minganensis* TWENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 47, pl. 7, figs. 10-12, 1938.

Horizon and locality.—Mingan formation (zone 10) in Mingan group: Quarry and Eskimo Islands.

MIMELLA NUCLEA (Butts)

Plate 85, B, figures 13-26

Orthis nuclea BUTTS, Alabama Geol. Surv., Special Rep. 14, pl. 22, fig. 6, 1926.

Small, subquadrate in outline, valves of unequal depth, the brachial valve having a slightly greater depth than the pedicle one. Cardinal extremities rounded, obtuse; lateral margins gently rounded, anterior margin broadly rounded to subtruncate; anterolateral extremities narrowly rounded. Surface multicostate, most of the costae extending directly from the beak to the anterior margin but a few may be intercalated; from 7 to 9 costae occupy 5 mm. at the front margin depending on the size.

Pedicle valve semipyramidal, unequally convex in lateral profile with the greatest curvature in the posterior third; front two-thirds flattened. Umbonal region narrowly convex with moderately steep slopes to the cardinal extremities. Median region with poorly defined fold in the young, the fold extending to about the middle in adults but the front part of the valve anterior to the fold flattened or slightly sulcate. Flanks gently convex. Palintrope long, producing a pointed beak which is slightly incurved; interarea strongly apsacline.

Brachial valve moderately convex in lateral profile, fairly strongly convex in anterior profile; umbo marked by a narrow and shallow sulcus that extends anteriorly to the front margin where it occupies a third or less of the width. Slopes from umbo and flanks steep; flanks somewhat narrowly rounded; interarea fairly long for the genus, apsacline in position.

Pedicle interior with large muscle area which is slightly longer than wide; diductor scars elongate, adductor track elevated at the front end; adjustor impressions long and slender. Brachial interior with median ridge reaching about to the middle of the valve; cardinal process long and slender; notothyrial cavity wide, supporting plates of brachioophores thick, wide, and shallow.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.4 | ? | 9.7 | ? | ? |
| Hypotype (110773d)..... | 9.5 | 7.9 | 10.4 | 9.0 | 6.8 |
| “ (110773b)..... | 11.3 | 10.8 | 13.9 | 10.7 | 6.6+ |
| “ (110773a)..... | 12.4 | 11.4 | 14.3 | 11.0 | 8.7+ |

Types.—Holotype: 71487; figured hypotypes: 110773a-d.

Horizon and locality.—Lenoir formation in Alabama: 2 miles west-southwest of Pratts Ferry, southwest of Montevallo.

Lenoir formation (lower 100 feet) in Tennessee: $1\frac{1}{2}$ miles south of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle; $\frac{3}{4}$ mile northeast of Friendsville; south side of cemetery at Quaker Church, northwest corner Friendsville; Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species hitherto has been referred to in literature on the Southern Appalachians as Raymond's species *Hebertella vulgaris*, but several significant differences may be noted. The Champlain Valley species has a wider hinge and the cardinal extremities are much more prominent than those of the Tennessee specimens. The southern species is much less regular in outline and has a longer interarea, a longer and more curved beak. The costae in both species are very regular and direct. In both, intercalations take place only at the umbo and the number of costae is about the same. Nevertheless, those of *M. nuclea* are separated by somewhat wider intercostal spaces which give the species the appearance of being somewhat coarser ribbed than it is.

Mimella nucleoidea resembles the southern species, but it has different ribbing and had both valves more convex than those of *M. nuclea*. The latter is a fairly common species in the calcarenites associated with the Lenoir formation. It is also found in shales particularly around Philadelphia, Tenn. It occurs in calcarenites from Alabama to southern Virginia.

MIMELLA NUCLEOIDEA Cooper, new species

Plate 87, B, figures 6-15

Hebertella vulgaris RAYMOND (part), Ann. Carnegie Mus., vol. 7, No. 2, p. 242, text figs. 15, 17, 18, pl. 36, figs. 2, 4, 5?, 1911.

Small, wider than long, subrectangular in outline, sides gently rounded and anterior margin broadly rounded; greatest width at or anterior to the middle; anterior commissure rectimarginate. Hinge narrower than the shell width; cardinal extremities obtuse, not prominent. Multicostellate, about 9 costellae in 5 mm. at the front margin. Costellae narrowly rounded, separated by spaces having a width about equal to the width of the costellae. Costellae increasing by intercalation and bifurcation, particularly at about midlength of the valve; anterior intercalations scattered and usually few.

Pedicle valve moderately convex in lateral profile, most convex in the posterior half, somewhat flattened anteriorly; broadly and gently convex in anterior profile; posterior and umbonal region moderately swollen, anterior region broadly flattened; lateral areas gently rounded but with short, steep slopes to the cardinal extremities. Beak long, moderately incurved; interarea long, strongly apsacline.

Brachial valve in lateral profile evenly and moderately convex with the greatest convexity at about the midlength; anterior profile strongly and broadly rounded with short, steep lateral slopes; umbonal region swollen; beak strongly incurved and overhanging the pedicle interarea; umbo depressed medianly by a shallow sulcus that widens slightly anteriorly and extends nearly to the anterior margin; sulcus never prominent and often disappearing at the front margin.

Median region strongly swollen and with steep but short slopes to the lateral margins and cardinal extremities.

Interior of pedicle valve with well-developed dental plates and strongly impressed muscle field. Diductor scars long and narrow; adductor ridge prominent, elevated, and somewhat elongated; adductor scars crescentic. Brachial valve with short, elevated median ridge; notothyrial cavity deep; brachiphores short, supporting plates thick, moderately elevated anteriorly; cardinal process a simple ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.6 | 10.4 | 14.2 | 10.6 | 8.9 |
| Paratype (110804a) | 11.6+ | 10.7 | 13.3 | 10.8 | 8.2 |

Types.—Holotype: 110786; figured paratypes: 110804a, 110797a,b; unfigured paratypes: 110804b-e, 110797c.

Horizon and locality.—Crown Point formation in New York: Sloop Bay, Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This species is characterized by its narrow hinge, strongly convex valves and numerous intercalated costellae. It differs from *M. vulgaris* Raymond in its convex valves, numerous costellae, narrow hinge, and less strongly apsacline interarea. It suggests *M. nuclea* but is more convex, has a less apsacline interarea, somewhat narrower hinge, and more numerous costellae.

MIMELLA PIGER (Billings)

Plate 99, D, figures 20-23

Orthis piger BILLINGS (in part), Canadian Nat., vol. 4, pp. 442, 443, 1859.

Plectorthis ? piger (Billings) TWENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 48, pl. 7, figs. 7-9, 1938.

Cooper examined the specimen figured by Twenhofel and Whiting and identified it as a *Mimella* rather than a *Plectorthis*. The ribbing, profile, and length of interarea of the pedicle valve are wrong for *Plectorthis*. It does not seem to be the same as "*Plectorthis*" *exfoliata* (Raymond).

Type.—Hypotype: Y.P.M. 15823.

Horizon and locality.—Mingan formation in Mingan group: On Parroquet and Eskimo Islands.

MIMELLA SIMILIS Cooper, new species

Plate 91, B, figures 8-12; plate 91, C, figures 13-18; plate 92, D, figures 23-28

Shell of about medium size for the genus, wider than long; subrectangular in outline; sides moderately rounded; anterior margin broadly rounded; anterior commissure nearly rectimarginate to gently uniplicate. Hinge narrower than the greatest shell width which is anterior to the middle; cardinal extremities forming a small obtuse angle. Multicostellate, costellae narrowly rounded and elevated, closely crowded, 3 in the space of 1 mm. at the front margin.

Pedicle valve unevenly convex in lateral profile with the posterior half moderately convex and the anterior half depressed toward the brachial valve. Anterior profile broadly and gently convex, the median region forming the crest of the arch. Beak erect and only slightly incurved; umbo somewhat narrowly swollen; posteromedian region gently swollen; anteromedian area depressed to form a shallow sulcus; flanks bounding sulcus slightly swollen; lateral slopes gentle but steepening toward the cardinal extremities. Interarea moderately long, nearly catacline.

Brachial valve fairly evenly and moderately convex in lateral profile; anterior profile strongly convex with long and steep lateral slopes. Umbonal region narrowly convex and merging into the swollen median region. Fold not pronounced, defined as a broad swelling of the anterior; lateral slopes long; cardinal extremities prominent. Interarea moderately long, curved over the pedicle interarea.

Interior of pedicle valve with strongly elevated adductor track and long, narrow diductor troughs.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.9 | 13.0 | 16.0 | 13.0 | 7.8 |
| Paratype (117046b) | 16.0 | ? | 19.6 | 15.3 | ? |
| " (117048a) | 14.3 | 13.5 | 17.0 | 12.7 | 8.6 |

Types.—Holotype: 117046a; figured paratypes: 110737, 117046b, 117047a, 117048a; unfigured paratypes: 117047b,c.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 0.2 mile northwest up farm lane, $\frac{1}{2}$ mile southwest of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle; 500 feet below "Holston" marble, Lee Valley Post Office, Lee Valley (T.V.A. 171-NW) Quadrangle; $\frac{1}{2}$ mile southwest of Beeler Cemetery, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; 2 miles southwest of Hall Crossroad, northwest quarter center subquad., Fountain City (T.V.A. 146-SW) Quadrangle; Evans Ferry, Howard Quarter (T.V.A. 162-NW) Quadrangle; 1 mile southeast of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 2.65 miles southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; Red Hill, $4\frac{1}{4}$ miles southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; 3 and $3\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; stream and road crossing on U. S. Highway 25E, $\frac{1}{2}$ mile north of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; Raccoon Valley, 5 miles south of Clinton, Powell Station (T.V.A. 137-SE) Quadrangle.

Discussion.—This is a species of moderate size suggesting small examples of *Mimella globosa*. Confusion with the latter species is easy because the Hogskin shale has been called Ottosee, parts of which are the source yielding *M. globosa*. The two species may be distinguished by the smaller size of the Hogskin form which generally has prominent and slightly obtuse cardinal extremities, a somewhat more convex and deeper pedicle valve, more strongly apsacline interarea. This species differs from *M. tumida* in its much smaller size and finer costellae.

MIMELLA SUBQUADRATA Cooper, new species

Plate 92, B, figures 5-9

Moderately large for the genus, width slightly greater than the length; brachial valve somewhat deeper than the pedicle valve; sides nearly straight; cardinal extremities nearly a right angle, anterolateral extremities narrowly rounded; anterior margin gently emarginate; anterior commissure gently and broadly uniplicate. Surface marked by 9 or 10 narrowly rounded costellae in 5 mm. at the anterior margin; striae narrower than the width of the costellae at the anterior margin.

Pedicle valve in lateral profile unevenly convex, the posterior half flatly convex but the anterior half sloping moderately toward the brachial valve; anterior profile broadly and gently convex; umbonal region gently convex; median region flattened and anterior third depressed into a broad and shallow sulcus. Posterolateral slopes short and steep. Interarea nearly flat, perceptibly apsacline; beak slightly curved.

Brachial valve fairly strongly and evenly convex in lateral profile with the maximum convexity at about the middle; anterior profile steeply domed and with long, steep lateral slopes; umbonal and median regions strongly swollen; antero-median region somewhat flattened; umbonal region swollen; beak strongly overhanging pedicle interarea; umbo with a short, barely perceptible sulcus not visible anteriorly; cardinal extremities prominent as small ears.

Measurements in mm.—Holotype, length 16.7, brachial length 17.5, width 19.3, hinge width 18.5, thickness 13.4.

Type.—Holotype: 117050a; unfigured paratypes: 117049a,b, 117050b, 117051a-c.

Horizon and locality.—Bromide formation (Mountain Lake member-lower *Sowerbyites* bed) in Oklahoma: 25 to 46 feet above the Bromide sand on Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is characterized by a subquadrate outline, strongly convex brachial valve, nearly catacline interarea, and fairly strong costellae. It is most like *M. intermedia* in shape but differs in having a more convex brachial valve, stronger costellae, and larger size. In the same respects *M. subquadrata* differs from narrow forms of *M. extensa*.

MIMELLA SULCATA Cooper, new species

Plate 87, D, figures 20-24

Large, somewhat transversely elliptical in outline; length about four-fifths the width; valves subequal in depth; hinge width about equal to the length; lateral extremities somewhat narrowly rounded; anterior margin nearly straight; anterior commissure narrowly uniplicate; surface costellate, 3 in 1 mm. at the front margin.

Pedicle valve moderately convex in lateral profile and with the greatest convexity in the posterior half; anterior profile strongly and broadly convex; umbonal and posterior third to half swollen; sulcus short, deep, narrow, originating at

about the middle; tongue short and narrowly rounded; lateral slopes steep; interarea moderately long, apsacline; beak incurved.

Brachial valve moderately convex in lateral profile but with the greatest convexity at the middle; anterior profile slightly more convex and with somewhat steeper lateral slopes than those of the pedicle valve; umbonal region somewhat flattened; median area strongly inflated; anterior region moderately convex but not forming a pronounced fold, the tongue of the pedicle valve inserted into a reentrant wave of the brachial commissure.

Measurements in mm.—Holotype, length 20.2, brachial length 18.2, width 26.0, hinge width 18.9, thickness 14.4.

Type.—Holotype: 117053.

Horizon and locality.—Benbolt formation in Virginia: On the north side of U. S. Highway 19, $1\frac{3}{4}$ miles southeast of Hansonville Post Office, Brumley (T.V.A. 205-SE) Quadrangle.

Discussion.—This is a rare species; only one specimen has been found up to the present writing. This species suggests *M. biconvexa* and *M. globosa*. It differs from both of them in the somewhat narrow brachial fold of the anterior commissure and the small, narrow pedicle tongue. Another characteristic feature separating this species from the two mentioned and from most other *Mimella*s is the flattened umbo of the brachial valve.

MIMELLA TRANSVERSA Cooper, new species

Plate 85, D, figures 33-37

Shell of about medium size for the genus, transversely subrectangular in outline; sides broadly rounded; greatest width anterior to the middle; anterolateral extremities narrowly rounded; anterior margin nearly straight; anterior commissure broadly and faintly uniplicate. Valves subequal in depth. Surface multicostellate, about 8 or 9 costellae in 5 mm. at the anterior margin; costellae narrowly rounded and separated by striae narrower than the width of the costellae.

Pedicle valve unevenly and moderately convex in lateral profile and with the maximum convexity in the posterior half, anterior half flattened; anterior profile broadly subtriangular with long, gently sloping sides and low, rounded apex; umbonal and median regions swollen; anteromedian area flattened, posterolateral slopes long and moderately steep; interarea moderately long, apsacline; beak erect.

Brachial valve fairly evenly convex in lateral profile with the maximum convexity in the median region; anterior profile strongly and broadly convex with the top gently flattened but with short, steep lateral slopes; umbonal and median regions swollen. Sulcus originating on the umbo, shallow and inconspicuous, widening moderately anteriorly and bounded by low, narrow swellings; lateral slopes long and moderately steep. Beak partially overhanging pedicle interarea.

Measurements in mm.—Holotype, length 14.5, brachial length 14.0, width 19.4, hinge width 14.2, thickness 10.1.

Type.—Holotype: 117052.

Horizon and locality.—Valcour formation in New York: On Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This is a fairly large species characterized by a nearly recti-marginate anterior commissure, sulcate brachial valve, and numerous costellae. The species is somewhat more strongly costellate than the Southern Appalachian species but is more finely costellate than the common New York *M. vulgaris*. It is also larger than that species and *M. nucleoidea*. It suggests *M. extensa* in ornamentation but has a much narrower hinge.

MIMELLA TUMIDA Cooper, new species

Plate 89, B, figures 15-23

Shell fairly large for the genus, wider than long; subrectangular in outline; sides moderately rounded; anterior margin broadly rounded; anterior commissure gently uniplicate; hinge equal to about two-thirds the width; cardinal extremities obtusely rounded; greatest width near the middle. Multicostellate, costellae narrowly rounded, somewhat crowded, often fasciculate on parts of the shell, about 2 to the millimeter at the front margin of an adult.

Pedicle valve fairly strongly convex in lateral profile with most of the convexity in the posterior half and with the front half somewhat flattened; anterior profile fairly strongly convex and forming a dome with fairly steep sides. Umbonal region somewhat narrowly swollen; posteromedian region gently swollen and with long, steep slopes to the cardinal extremities; anterior half somewhat flattened and in the median region along the margin depressed into a shallow sulcus. Interarea curved, apsacline; beak incurved.

Brachial valve in lateral profile fairly strongly convex, the posterior part the most convex; anterior profile strongly convex and forming an arch highest in the middle and with long, steep lateral slopes. Umbonal region inflated and somewhat elevated posterior to the posterior margin; median region swollen; anterior somewhat flattened. Interarea strongly curved over the pedicle interarea; beak prominent.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 21.5 | 21.0 | 24.9 | 16.7 | 14.8 |
| Paratype (110739) | 13.6 | 12.9 | 16.3 | 13.6 | 9.2 |

Types.—Holotype: 110714; figured paratype: 110739.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; Maynardville Pike, 1.7 miles north of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; Evans Ferry, Howard Quarter (T.V.A. 162-NW) Quadrangle; $4\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Discussion.—This species is like *M. globosa* and approaches that species in size, although the biggest specimens of *M. tumida* are smaller than the largest

ones of *M. globosa*. In general *M. tumida* is more strongly costellate than the general run of *M. globosa*, but it is suggestive of the more strongly costellate ones called *M. superba* by Dr. Butts. However, the pedicle valve of the Hogskin species is more tumid than that of *M. globosa*.

MIMELLA ULRICHI Cooper, new species

Plate 87, A, figures 1-5

Shell small for the genus, transversely rectangular in outline; sides rounded; cardinal extremities obtusely rounded; anterior margin emarginate medially; anterior commissure gently and broadly sulcate. Multicostellate, costellae narrowly rounded, closely crowded, increasing by bifurcation, often fasciculate.

Pedicle valve evenly and gently convex in lateral profile; broadly convex in anterior profile with the median region rounded and long, moderate slopes to the margins. Umbonal region swollen, the swelling continuing anteriorly but increasingly indistinct to the front margin and thus serving as a poorly defined fold. Flanks gently convex and sloping moderately to the margins. Interarea curved, nearly catacline; beak gently incurved.

Brachial valve having less depth than the pedicle valve, gently but evenly convex in lateral profile. Anterior profile broadly convex but depressed slightly in the median region and with moderately long and moderately steep lateral slopes. Umbo sulcate; sulcus shallow throughout its length, originating at the beak and extending to the front margin. Flanks bounding sulcus gently swollen; lateral slopes moderately short. Interarea short, anacline.

Measurements in mm.—Holotype, length 7.9, brachial length 7.2, width 10.7, hinge width 9.4, thickness 4.8.

Types.—Holotype: 110805.

Horizon and locality.—Crown Point formation in New York: At Sloop Bay, Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This little species is characterized by its transversely rectangular outline, strongly sulcate brachial valve, wide hinge, and fine costellae. It occurs with *M. nucleoidea* but is readily distinguished by its greater width.

MIMELLA VALCOURENSIS Cooper, new species

Plate 85, C, figures 27-32

Shell of about medium size for the genus; wider than long and with a somewhat rectangular outline; depth of valves subequal; greatest width anterior to the middle; lateral margins sloping obliquely anteriorly to the narrowly rounded anterolateral extremities. Anterior margin slightly emarginate; anterior commissure broadly and gently uniplicate. Surface multicostellate, costellae broad, crowded, 8 or 9 in the space of 5 mm. at the anterior margin of the flanks, narrower and more crowded in the midregion.

Pedicle valve having unequal convexity, the most convex part in the posterior half, the anterior half sloping steeply toward the brachial valve; anterior profile

moderately convex, somewhat flat topped and with short, steep lateral slopes; umbonal region swollen; sulcus shallow and broad, originating about 5 mm. anterior to the beak; flanks bounding sulcus gently swollen; umbonal slopes to the cardinal extremities steep. Interarea long, catacline, but with strongly and narrowly incurved beak.

Brachial valve strongly convex and with the greatest convexity in the posterior half; anterior half sloping moderately to the pedicle valve; umbonal region strongly convex; beak strongly incurved and overhanging the pedicle interarea; median region broadly sulcate, sulcus originating anterior to the umbo, broad and shallow, poorly defined at the front margin. Lateral slopes short and steep.

Measurements in mm.—Holotype, length 13.8, brachial length 13.3, width 17.2, hinge width 13.5, thickness 11.3.

Type.—Holotype: 110792.

Horizon and locality.—Probably Valcour formation in New York: On Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This species is similar in ornamentation to *M. transversa* but differs markedly in having both valves much more tumid and in being much less transverse. The interarea is longer and the beak narrower than *M. transversa*, and the brachial valve has a more strongly arched umbonal region. *Mimella valcourensis* is a rare species; only a single specimen is now known.

MIMELLA VIRGINIENSIS Cooper, new species

Plate 37, B, figures 5-7; plate 91, H, figures 35, 36

Mimella sp. BUTTS, Virginia Geol. Surv. Bull. 52, p. 43, pl. 73, figs. 47-52, 1942.

Shell large, wider than long, with well-rounded sides and gently rounded anterior margin. Hinge narrow; anterior commissure very gently uniplicate. Surface multicostellate, costellae numbering 10 to 5 mm. at the front margin.

Pedicle valve fairly evenly and gently convex in lateral profile but with anterior somewhat flattened. Anterior profile broadly and moderately convex. Umbonal and median regions swollen; anterior region gently inflated except for median quarter which is depressed to form a shallow sulcus. Posterolateral slopes somewhat inflated but steeply inclined to the cardinal extremities. Interarea long, apsacline; beak very gently incurved.

Brachial valve strongly convex in lateral profile and with the maximum convexity at about the middle; anterior profile strongly arched, with steep and long lateral slopes. Whole median region and umbo strongly swollen. Lateral slopes long and steep. Interarea short.

Measurements in mm.—Holotype, length 18.5, brachial length 17.2, width 22.6, hinge width 16.8, thickness 12.9.

Types.—Holotype: 98188a, figured paratype: 110694; unfigured paratypes: 98188b-e.

Horizon and locality.—Whistle Creek formation in Virginia: 1½ miles northwest of Lexington, Lexington (15') Quadrangle; top of the ridge 1,000 feet

north of the road on Buffalo Creek, $2\frac{1}{2}$ miles west of Murat, Natural Bridge (15') Quadrangle.

Discussion.—This species is characterized by its fairly large size and strongly convex valves. In these respects it is similar to *M. biconvexa* and *M. globosa*. It differs from the former in having a rectimarginate anterior margin, and from the latter in having a much more strongly convex pedicle valve. This species is different from all the pre-Benbolt species in the subequal depth of its valves. It is more finely costellate than *M. tumida* and is larger and more convex in both valves than *M. laticardinia*.

MIMELLA VULGARIS (Raymond)

Plate 85, A, figures 1-12; plate 92, E, figures 29-33

Hebertella vulgaris RAYMOND, Ann. Carnegie Mus., vol. 3, p. 501, 1906; *ibid.*, vol. 7, No. 2, p. 242, text fig. 16, pl. 36, fig. 3, 1911.

Shell of about medium size for the genus, somewhat variable; wider than long, somewhat rectangular in outline and generally with the hinge only slightly less than the width; cardinal extremities usually slightly obtuse. Sides very gently rounded; anterior margin broadly rounded; anterior commissure rectimarginate to faintly uniplicate. Surface costellate, costellae usually narrowly rounded, distant and numbering 6 to 9 in 5 mm. at the front margin at or near the middle. Costellae direct from umbo where bifurcation and intercalation takes place.

Pedicle valve unevenly convex in lateral profile, the posterior half gently convex and the anterior half flattened; anterior profile forming a broad triangle with long, gently sloping sides and broadly rounded apex. Umbonal region somewhat swollen, the swelling continuing to about the middle; anteromedian region flattened; lateral slopes short, steepening to the cardinal extremities. Beak gently curved; interarea moderately long and strongly apsacline.

Brachial valve moderately convex in lateral profile with maximum convexity in the umbonal region; anterior profile moderately domed and with steep lateral slopes; beak fairly strongly incurved; umbo and median region fairly strongly swollen; sulcus originating on the umbo at the beak, shallow and inconspicuous, widening slightly and nearly disappearing at the anterior margin. Flanks bounding sulcus moderately swollen and with short, steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (?) | 10.3 | 9.7 | 11.8 | 9.6 | ? |
| Hypotype (110790a) | 12.6 | 12.0 | 14.8 | 11.9 | 8.0 |
| " (117054) | 13.4 | 12.8 | 16.5 | 11.2 | 9.7 |

Types.—Holotype (?): Carnegie Mus. 5512; figured hypotypes: 110790a, 110796, 117054.

Horizon and locality.—Crown Point formation on Plattsburg (15') Quadrangle in New York: On the south end of Valcour Island; in an old quarry just west of New York Highway 9, southwest of Bluff Point, Lake Champlain; near the Normal School, $\frac{1}{2}$ miles north of Plattsburg.

Same formation in Vermont: Just north of the neck of Providence Island, Plattsburg (15') Quadrangle.

St. Martin formation in Quebec: At Belanger, 2 miles south of Cap St. Martin, Quebec.

Discussion.—This species is characterized by some primitive characters such as the direct costae, a fairly strongly sulcate brachial valve, and wide hinge. These features give the shell a distinctly hebertelloid appearance, but the pedicle muscle scars are those of *Mimella*. The species is closest to *M. nuclea* but differs from that species in its more regular form, wider hinge, and more convex valves.

MIMELLA WARDELLANA Cooper, new species

Plate 90, D, figures 35-38

Shell of about medium size for the genus, subrectangular in outline, wider than long. Sides fairly strongly rounded; anterior margin gently rounded to nearly straight; anterior commissure broadly uniplicate. Multicostellate, costellae low, rounded, crowded, about 13 in 5 mm. at the front margin.

Pedicle valve moderately convex in lateral profile with the most convex part in the posterior half, anterior half somewhat flattened. Anterior profile broadly and moderately convex. Umbonal region swollen; median region moderately convex; anteromedian half depressed to form a shallow and wide sulcus. Flanks bounding sulcus gently swollen. Lateral and posterolateral slopes long and only moderately steep. Tongue broad and rounded.

Brachial valve slightly deeper than the pedicle valve, fairly strongly convex in lateral profile and with the maximum convexity in the median region; anterior profile strongly convex with the maximum height of the arch in the median region and with long and steep slopes to the margins. Umbonal and median regions inflated; anteromedian area forming a moderately broad but indistinct fold. Lateral descent from median region long and steep to the margins and posterolateral extremities.

Pedicle interior with muscle field subquadrate in outline, the diductor tracks narrow and nearly parallel, the adductor scars situated on a tonguelike elevation protruding slightly anterior to the front margin of the field. Brachial valve with deep notothyrial cavity, high cardinal process, and stout median ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (brachial valve)..... | ? | 14.9 | 20.9 | 13.5 | 6.7 |
| Paratype (pedicle valve 117055b) .. | 16.3 | ? | 20.9 | 15.0 ? | 6.5 |

Types.—Holotype: 117055a; figured paratype: 117055b; unfigured paratype: 117055c,d.

Horizon and locality.—Wardell formation in Tennessee: In Raccoon Valley, $\frac{3}{4}$ mile northeast of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle.

Discussion.—This species is characterized by strongly convex valves and fine

costellae. It is also featured by a fairly narrow uniplicate wave in the anterior commissure suggestive of *M. sulcata*. It differs from that species in having a strongly swollen umbo and less convex pedicle valve.

MIMELLA sp. 1

Plate 91, D, figures 19-24

Shell of medium size, subrectangular in outline with the hinge narrower than the greatest width which is at the middle. Anterior commissure rectimarginate. Sides very gently rounded. Cardinal extremities prominent. Surface multicostellate, costellae uneven, crowded, about 11 in 5 mm. at the anterior margin.

Pedicle valve gently convex in lateral profile with the posterior half convex and the anterior half somewhat flattened. Anterior profile very gently and broadly convex. Umbonal and median regions gently swollen; anterior region flattened. Lateral and posterolateral slopes long and gentle. Interarea long and strongly apsacline; beak gently incurved.

Brachial valve evenly and moderately convex in lateral profile with the maximum convexity at about the middle. Anterior profile fairly strongly convex with long but moderately steep lateral slopes.

Measurements in mm.—117056a, length 16.2, brachial length 15.9, width 20.4, hinge width 18.0, thickness 10.4.

Figured specimens.—117056a,b.

Horizon and locality.—Elway formation in Tennessee: On U. S. Highway 25W, 4.7 miles south of Clinton, Powell Station (T.V.A. 137-SE) Quadrangle.

Discussion.—This species suggests *M. laticardinia* but has a few differences. The pedicle valve is somewhat more swollen, the interarea is more apsacline, the cardinal extremities less obtuse, and the umbo faintly sulcate. Only two specimens are available, both of which are imperfect; consequently, no specific name has been applied.

MIMELLA sp. 2

Plate 91, G, figures 29-34

Shell small to medium size for the genus, wider than long, hinge narrower than the greatest shell width at the middle. Sides rounded, anterior margin broadly rounded; anterior commissure rectimarginate. Surface multicostellate, costellae fine, closely crowded, numbering about 17 in 5 mm. at the front margin.

Pedicle valve gently convex in lateral profile; anterior profile broadly convex but the median ridge rounded and with long, gentle lateral slopes. Umbonal region somewhat swollen; median region gently inflated to form a poorly defined fold. Lateral areas flatly convex. Interarea strongly apsacline, gently curved.

Brachial valve gently convex in lateral profile; anterior profile gently and broadly convex, the median region slightly depressed. Umbo marked by a shallow sulcus that extends from the beak to the anterior margin. Flanks bounding sulcus gently swollen; posterolateral extremities prominent, marked off by long gentle slopes.

Measurements in mm.—117057, length 7.9, brachial length 8.2, width 10.7, hinge width 9.3, thickness 4.1.

Figured specimen.—117057.

Horizon and locality.—Tulip Creek formation in Oklahoma: 152 feet above the top of the basal sand, on the first creek east of U. S. Highway 77, SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County.

Discussion.—This is clearly an immature form probably not directly comparable to any of the described species.

MIMELLA sp. 3

Plate 91, J, figure 40

This is a large species which was taken from limestone of the Lincolnshire formation along the railroad just east of Strasburg Junction, Strasburg (15') Quadrangle. The brachial valve only is represented, but it indicates a species larger than *M. laticardinia*. It is 22 mm. long by 29 mm. wide.

Figured specimen.—117058b.

Family SKENIDIIDAE Kozłowski, 1929

Small subpyramidal Orthacea probably derived out of Finkelnburgiidae, having a free spondylium, a cruralium, and fulcral plates forming the sockets.

Genus SKENIDIODES Schuchert and Cooper, 1931

Skenidioides SCHUCHERT and COOPER, Amer. Journ. Sci., vol. 22, p. 243, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 71, 1932.

SKENIDIODES ANTHONENSIS (Sardeson)

Plate 98, H, figures 31-37

Skenidium anthonensis SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 333, pl. 4, fig. 7, 1892.

Scenidium halli HALL and CLARKE (part), Pal. New York, vol. 8, pt. 1, p. 242, pl. 7A, figs. 37-39, 1892.

Scenidium anthonensis (Sardeson) WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 381, figs. 20-23, 1893.

Skenidioides anthonensis (Sardeson) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 71, 1932.

Shell small for the genus, wider than long, width about twice the length; cardinal extremities acute; sides obliquely rounded and sloping toward the middle; anterior commissure strongly and narrowly sulcate; surface costate, 10 to 11 costae on each side of the fold and sulcus; fold marked by 3 or more costae, the outer 2 bifurcated, the inner ones may or may not be bifurcated depending on the size attained; sulcus with a similar arrangement.

Pedicle valve gently convex in lateral profile; broadly triangular in anterior profile; anterior commissure deeply emarginate at the fold; flanks bounding fold gently convex in anterior profile; fold only slightly elevated. Interarea long, beak gently curved.

Brachial valve slightly convex in lateral profile; gently and broadly convex in anterior profile; tongue short and narrowly rounded; sulcus deep, originating at the umbo; flanks bounding sulcus gently convex.

Measurements in mm.—Hypotype (24207a), length 1.4, brachial length 1.5, midwidth 2.9, hinge width 3.3, thickness 1.2.

Types.—Figured hypotypes: 24207a, 48911a,b.

Horizon and locality.—Platteville formation in Minnesota: At Minneapolis.

Same formation in Illinois: At Dixon, Dixon (15') Quadrangle.

Discussion.—This species is distinguished by its considerable width even in adult form, its fairly strong, sharp, and regular costae, and low fold. It has been the practice to place this species in the synonymy of *S. halli*, but it is actually a much smaller shell, with less numerous costae on the flanks, much lower fold, and a narrower and shallower sulcus. The Minnesota species is also suggestive of *S. perfectus* from the Bromide formation (Pooleville member), but that is a narrower species with more distant costae and stronger fold and sulcus.

SKENIDIOIDES BILLINGSI Schuchert and Cooper

Scenidioides billingsi SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 72, pl. 10, figs. 6, 8, 10-14, 1932.

Types.—Holotype: Y.P.M. 2013a.

Horizon and locality.—Rockland formation, Paquette Rapids in Canada: On Ottawa River, Ontario.

SKENIDIOIDES CONVEXUS Cooper, new species

Plate 99, E, figures 24-34

Shell of about medium size for the genus, width about twice the length; cardinal extremities acutely angular; sides gently rounded and directed obliquely toward the middle of the valve; anterior margin truncated; anterior commissure deeply sulcate. Surface costate, costae numbering 6 to 9 on the flanks and generally 5 on the fold.

Pedicle valve moderately to fairly strongly convex in lateral profile; anterior profile moderately and fairly evenly convex, the median region only moderately carinated by the fold. Fold formed by a fascicle of 5 costae, 2 bifurcating at the beak, 2 bifurcating just anterior to the beak, and the fifth implanted or bifurcated between the latter 2. One of the median ribs usually swollen and forming the crest of the fold. Flanks slightly swollen and merging gently into the fold; inter-area long and apsacline.

Brachial valve flat in lateral profile in the posterior half but bent toward the pedicle valve in the anterior half; anterior profile almost flat to gently convex; sulcus narrow and deep, occupied by 2 costae on its sides and 2 or 3 implanted at the front. Flanks narrowly but gently swollen; posterolateral areas flat to gently concave.

Interior of pedicle valve with short and shallow free spondylium; brachial

interior with narrow and shallow notothyrial cavity; brachiophore plates attached high on median septum.

Measurements in mm.—Holotype, length 2.4, brachial length 1.9, midwidth 3.2, hinge width 3.9, thickness 1.6.

Types.—Holotype: 117070a; figured paratypes: 117070b-d.

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile south of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species has a deep sulcus and moderately strong fold. The brachial valve is fairly deep, and the costae are strong. It differs from *S. costatus* in having a more convex brachial valve with a deeper sulcus. The shape of the Alabama species is also considerably different from that of the Virginia form.

SKENIDIODES COSTATUS Cooper, new species

Plate 97, D, figures 38-48

Shell of about usual size for the genus, wider than long, with acutely angular and slightly auriculate cardinal extremities, gently sloping lateral margins, and broadly rounded to truncate anterior margin. Lateral profile planoconvex. Surface marked by about 19 to 21 strong costellae in the adult. The costellae appear in 3 generations. In a young valve 1.5 mm. in length, 13 primary costae are present which increase by intercalation to 19 or 21. In all stages of growth the median costa is stronger and more elevated than the others and forms a fold. Intercalation on each side of median costa takes place about one-third the length from the beak.

Pedicle valve evenly and strongly convex in lateral profile with the greatest convexity located at about the middle; in anterior profile this valve is subcarinate and the central costa is slightly elevated above those forming the flanks. Flanks flat in profile and moderately steep. Interarea long, slightly curved near the beak, and strongly apsacline.

Brachial valve flat in anterior profile. Umbo slightly convex, but just anterior to it a narrow sulcus forms which deepens and widens rapidly anteriorly to occupy about half the width of the valve at the front. Seven costae occupy the sulcus. Shell surface between the costae bounding the sulcus and the cardinal extremities perceptibly but only slightly concave.

Interior: Pedicle valve with long, slender teeth and short, shallow free spondylium. Median septum of brachial valve moderately thick and greatly elevated, so that the valve is separated into two parts. Notothyrial cavity shallow and narrow; brachiophores long and slender.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------|--------|-------|-------------|-----------|
| Holotype | 3.0 | 4.2 | 4.9 | 1.7 |
| Paratype (117072i) | 1.5 | 3.0 | 3.7 | 0.7 |

Types.—Holotype: 117072f; figured paratypes: 117072a-c,i,j; unfigured paratypes: 117072d,e,g,h.

Horizon and locality.—Edinburg formation (lower Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle: 4 miles southwest of Bland.

Red Knobs formation in Tennessee: 6 miles east of Knoxville.

Discussion.—This species is characterized by the strength of its ornamentation, the strong median costa which forms a prominent fold, late intercalation of the secondary generation of costae, the deep and wide sulcus in the brachial valve, and the flatness of the same valve.

As the ornamentation is the most distinctive feature of this little shell, a few more remarks are necessary. A specimen 1.5 mm. in length may show only primary costellae, but two specimens actually somewhat shorter show intercalation of the secondaries on each side of the median costa, and occasional costae elsewhere on the front margin. The median costa maintains its individuality although the secondary costae intercalated on each side of it are also slightly elevated.

The interiors of both valves of this species are characterized by the robust development of septa and spondylium. The latter is short and shallow and supported by a considerable thickening at the posterior.

The outline and general form of *S. rectangulatus* are like those of *S. costatus*, but the former is less strongly costate and has a pedicle valve with more gentle lateral profile. The Benbolt species, *S. mediocostatus*, is fairly strongly costate, but it does not have as strong a fold and sulcus as *S. costatus*.

SKENIDIoidES ELONGATUS Cooper, new species

Plate 92, C, figures 10-22; plate 98, A, figures 1-5

Large for the genus, length and width approximately equal; in some specimens the width is the greater dimension, in others it is the length. Outline sub-pentagonal; sides rounded, sloping obliquely toward the middle; anterior margin somewhat narrowly rounded. Anterior commissure deeply sulcate. Surface costate, costae numbering 28 to 32, low and rounded and with intercostal spaces narrower than the costae. Costae mostly direct from beak to anterior margin, but intercalation takes place along the margin of large specimens. Fold with a primary bifurcation at the beak and 3 sets of intercalated costae anteriorly to produce 8 costae. Corresponding ribbing in sulcus.

Pedicle valve evenly and gently convex in lateral profile; anterior profile sub-carinate; beak often distorted; umbo narrowly swollen; fold narrowly convex; flanks flattened and steep to the margins. Interarea unusually long, strongly apsacline, curved and occasionally distorted.

Brachial valve gently convex in lateral profile with the anterior bent fairly strongly toward the pedicle valve; anterior profile broadly and gently convex but with the median region sulcate. Sulcus originating about $\frac{1}{2}$ mm. anterior to the beak, widening and deepening anteriorly to occupy nearly half the width at the front margin. Tongue moderately long and rounded. Flanks bounding sulcus narrowly rounded; posterolateral areas flattened to gently concave.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 7.9 | 6.7 | 7.3 | 7.1 | 4.3 |
| Paratype (117073b)..... | 7.0 | 6.0 | 6.4 | 6.8 | 4.0 |
| “ (117073c)..... | 5.5 | 4.3 | 5.8 | 6.0 | 3.2 |
| “ (117073d)..... | 6.2 | 4.9 | 7.0 | 7.3 | 3.5 |

Types.—Holotype: 117073a; figured paratypes: 117073b,c,e; unfigured paratype: 117073d.

Horizon and locality.—Martinsburg formation (lower part with *Brongniartella*=Salona), in Virginia: On Virginia County Road 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This is the largest species yet found in the middle Ordovician rocks of the United States. It is not therefore directly comparable to any of the other species herein described. Young stages suggest *S. rectangulatus* but usually are somewhat wider than that species and with a shallower sulcus.

SKENIDIOIDES HALLI (Hall and Clarke)

Plate 98, G, figure 30

Skenidium halli SAFFORD, Geol. Tennessee, p. 287 (not defined), 1869.

Scenidium halli Safford (in part) HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 242, pl. 7A, figs. 33-36, 1892.

Fairly large for the genus, wider than long and with the hinge usually forming the greatest width. Valves unequally convex and of unequal depth, the pedicle valve having the greater depth. Anterior commissure strongly sulcate. Surface costate; costae varying in number from about 25 to 35. Increase in number of costae taking place by intercalation, most of the costae being primary; intercalation most frequent near the front of the fold. Costae crowded in the median region.

Pedicle valve hemipyramidal; gently convex in lateral profile and strongly arched to subcarinate in anterior profile. Umbo gently convex. Fold originating about one-fifth the length from the beak; fold low posteriorly, elevating and widening anteriorly to occupy about one-third the width. Flanks immediately adjacent to fold flat to slightly concave; slope of flanks to margins moderately steep. Interarea long, strongly apsacline to nearly procline.

The young brachial valve is nearly flat, but with growth the shell becomes gently to moderately convex with a tendency to a weak geniculation of the anterior. The sulcus originates near the beak and increases rapidly in depth and width to the front where a short tongue is developed. As many as 9 costae may occupy the sulcus at the front. Flanks bounding sulcus gently swollen; areas between flanks and cardinal extremities gently concave.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (pedicle valve 117074a)..... | 3.3 | ? | 4.5 | 5.0 | ? |
| “ (brachial valve 117074c).... | ? | 2.6 | 4.4 | 4.2 | ? |

Types.—Figured hypotype: 117074; measured hypotypes: 117074a,c.

Horizon and locality.—Lebanon limestone in western Tennessee: At Columbia, Maury County; 3 miles east of Murfreesboro, Rutherford County; Lavergne, Rutherford County; cut on U. S. Highway 241, 2.1 miles north of the Bedford-Rutherford County line in Rutherford County; behind Roy Holt's gasoline station on Tennessee Highway 10, 1.2 miles south of Lebanon town limits, Wilson County.

Discussion.—This species is abundant in the Lebanon limestone of the Central Basin of Tennessee but is rare elsewhere. It can be recognized by the moderate convexity of the brachial valve, the strong median sulcus, but more particularly by the fasciculate arrangement of the costae on the fold. This type of fasciculation is common in many of the species of this genus, and it is to those species that *S. halli* must be compared.

Skenidioides halli is about the same size as *S. platys*, but the Lebanon limestone species possesses a more convex profile in both valves. *Skenidioides oklahomensis* is suggestive of the West Tennessee species but is somewhat bigger, more angular, with a stronger fold and sulcus and stronger costae.

SKENIDIOIDES MEDIOCOSTATUS Cooper, new species

Plate 97, C, figures 19-37

Shell fairly large for the genus, with the hinge forming the widest part. Lateral margins sloping toward the middle; anterolateral extremities broadly rounded and the anterior margin truncate. Anterior commissure strongly sulcate. Profile planoconvex. Ornamentation variable, a broad central costa flanked by 9 to 12 costae. Most costae primary; intercalated costae few and occurring chiefly on each side of the median costa.

Pedicle valve slightly convex in lateral profile; more strongly convex in anterior profile. Umbo slightly convex; fold increasing in prominence gradually to the anterior margin. Flanks flat in profile, their slope moderate. Interarea long, nearly flat and nearly procline. Spondylium broad and shallow.

Brachial valve nearly flat in all profiles; sulcus originating at the umbo and extending to the front margin where it occupies somewhat less than half the width; 5 to 6 costae occupy the sulcus. Flanks bounding sulcus slightly convex. Region between flanks and cardinal extremities very slightly concave.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 3.0 | 2.5 | 4.0 | 4.5 | 2.0 |
| Paratype (117075b) | 2.6 | 2.5 | 4.0 | 4.7 | 1.5 |
| " (117075a) | 2.5 | 2.6 | 3.9 | 4.4 | 1.3 |

Types.—Holotype: 117076a; figured paratypes: 117075a-c, 117077c,d,j; unfigured paratypes: 117076b, 117077a,b,e-i,k,l.

Horizon and locality.—Benbolt formation in Virginia: In the vicinity of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, 1½ miles due south of Hansonville, Hansonville (T.V.A.

205-SW) Quadrangle; north side of Highway 19, about 1 mile due north of Belfast Mills, Saltville (T.V.A. 212-NE) Quadrangle.

Chatham Hill formation in Virginia: Virginia Highway 113, Marion-Chatham Hill road, 6 miles north of Marion, Chatham Hill (T.V.A. 218-NE) Quadrangle.

Discussion.—This species is characterized by its angular outline, strong costae on the flanks bounding the fold, narrow and moderately deep sulcus, and low fold marked prominently by 1 costa stronger than the others in a fascicle numbering about 5 costae. To compare with *S. costatus* see discussion under that species. It is suggestive of *S. rectangulatus* but differs in its less rectangular form, lesser length, and deeper, narrower sulcus. The ornamentation of *S. convexus* is not unlike that of *S. mediocostatus*, but the former species is more transverse and has a deeper sulcus. The form of *S. obtusus* is like that of the Benbolt species, but it has more numerous ribs, a hinge narrower than the greatest shell width, and a less deep sulcus.

SKENIDIIOIDES OBTUSUS Cooper, new species

Plate 97, B, figures 13-18

Shell of about medium size for the genus, wider than long; subrectangular in outline; hinge as wide as, or slightly narrower than, the greatest width which is near the middle; cardinal extremities rounded, obtuse or nearly a right angle in the adult, auriculate in the young; sides rounded; anterior margin broadly rounded; costae numbering 10 or 11 on the flanks; narrowly rounded and with intercostal spaces about equal to the width of the costae; fold and sulcus marked by a number of costae varying from 5 to 9.

Pedicle valve gently convex in lateral profile with the umbo somewhat more convex than the rest; anterior profile subcarinate and strongly convex, the pedicle valve having great depth; fold low, best defined at the front; flanks gently swollen but with steep slopes to the margins. Interarea long, with large delthyrium, strongly apsacline.

Brachial valve slightly convex in lateral profile, nearly flat in anterior profile; sulcus only moderately deep but marked centrally by a narrow and deep trough corresponding to the median costa of the pedicle valve; width of sulcus not equal to half the shell width. Flanks bounding sulcus gently swollen; posterolateral areas varying from gently convex to gently concave.

Interior of pedicle valve with moderately deep free spondylium; brachial interior with deep, wide, and long notothyrial chamber; brachioophore plates low on median septum.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 3.3 | 3.0 | 4.5 | 4.2 | 2.2 |
| Paratype (117078c)..... | 2.6 | 2.4 | 3.7 | 3.4 | 1.7 |

Types.—Holotype: 117078a; figured paratype: 117078b, unfigured paratypes: 117078c,d.

Horizon and locality.—Edinburg formation (shale near middle of the *Nidulites* zone) in Virginia: 100 yards south of Battlefield Crystal Cavern entrance on U. S. Highway 11 at Hupp Hill, 1 mile north of Strasburg, Strasburg (15') Quadrangle.

Discussion.—The chief feature of this species is the narrow hinge, and in this respect it is unlike any of the others described herein except *S. elongatus*, but it is much smaller than that species. This species is like *S. rectangulatus* but differs in strength of costae and narrower hinge.

SKENIDIODES OKLAHOMENSIS Cooper, new species

Plate 97, A, figures 1-12; plate 98, E, figures 24-27

Shell large for the genus, wider than long, with the width not quite twice the length. Cardinal extremities acutely angular; sides gently rounded, sloping obliquely toward the middle. Anterior margin narrowly rounded; anterior commissure widely and deeply sulcate. Surface costate, costae numbering about 30 on an adult; costae narrowly rounded; intercostal spaces narrower than the costae; except for the fold, intercalations few and near the front margins.

Pedicle valve deep, nearly flat in lateral profile in the young but gently convex in adults; anterior profile broadly convex with median region somewhat carinate. Fold originating at beak, marked by a complicated fascicle consisting of a thickened median costa on the side of which 2 or more costae are implanted. This median costa intercalated between 2 primary costae at beak. Flanks bounding sulcus gently convex and with moderate slopes to the sides; interarea long, nearly catacline in the young, strongly apsacline in adults.

Brachial valve unevenly convex in lateral profile, the posterior half nearly flat but the anterior half convex and bent strongly toward the pedicle valve; anterior profile broadly convex; umbo flat; sulcus originating a fraction of a millimeter anterior to the umbo, widening and deepening anteriorly but with a deeper, narrow track in the median part which corresponds to the thickened costa of the fold; sulcus occupied by 8 costae; width of sulcus not quite equal to half the shell width. Flanks bounding sulcus narrowly and gently inflated; posterolateral extremities gently concave.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 3.8 | 3.5 | 5.4 | 6.0 | 2.2 |
| Paratype (117079b)..... | 4.0 | 3.5 | 4.6 | 5.6 | 2.5 |
| " (117079c)..... | 3.4 | 3.0 | 3.8 | 4.6 | 1.9 |
| " (117079d)..... | 2.6 | 2.6 | 4.4 | 5.0 | 1.7 |

Types.—Holotype: 117079a; figured paratypes: 117079d-f, 118007a-d; unfigured paratypes: 117079b,c, 118007e-g.

Horizon and locality.—Bromide formation (Mountain Lake member) 30 to 34 feet below top of Decker's bed 10 in Carter County, Okla.; On Tulip Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1. E.; north of the middle of sec. 32, T. 2 S., R. 2 E., 2 miles northeast of Springer.

Discussion.—This species attains a fairly large size and is therefore comparable to *S. halli*, *S. transversus*, and *S. rectangulatus*. It is characterized by strong, direct, and somewhat distant costae, strong fold and sulcus, and nearly catacline interarea. *Skenidioides oklahomensis* differs from *S. halli* in its larger size, stronger and more distant costae, catacline interarea, and narrower and deeper sulcus. *Skenidioides transversus* is more transverse, as its name implies, than the Oklahoma species, and its fold and sulcus are much less pronounced. *Skenidioides rectangulatus* approaches the Oklahoma species in size, costation, and strength of fold and sulcus but differs in proportions. Its lateral extremities are squarer and the outline more quadrate.

SKENIDIOIDES PERFECTUS Cooper, new species

Plate 97, E, figures 49-54; plate 98, D, figures 18-23

Shell of about medium size for the genus, wider than long, not quite twice as wide as long; cardinal extremities acute; sides sloping steeply toward the middle and gently rounded; anterior margin nearly straight or medially emarginate. Anterior commissure deeply sulcate. Surface costate, 6 costae on the fold, 8 to 9 on the flanks and 6 to 8 in the sulcus; costae and intercostal spaces of about equal width.

Pedicle valve gently convex in lateral profile; anterior profile subcarinate; fold prominent, elevated, formed by a fascicle of costae; fascicle formed by a single rib which bifurcates after 1 mm., another bifurcated median rib located inside the bifurcation; median fascicle with a costa on each side at the base of the fold. Flanks bounding fold barely convex. Interarea long, posterior margin nearly straight, and beak low and inconspicuous; interarea nearly catacline.

Brachial valve in lateral profile flat in the posterior half but convex toward the pedicle valve in the anterior half; anterior profile perceptibly convex but with the median region narrowly sulcate. Sulcus originating at the beak which is smooth and flat; sulcus deepening and widening anteriorly but not equaling half the width at the front margin; flanks bounding sulcus perceptibly convex; posterolateral extremities gently concave.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 2.2 | 2.2 | 3.4 | 3.9 | 1.4 |
| Paratype (117081) | 2.6 | 2.4 | 3.8 | 4.1 | 1.6 |

Types.—Holotype: 117080; unfigured paratype: 117081; figured specimens: 117082b,c, 109987d.

Horizon and locality.—Bromide formation (Pooleville member—*Oxoplectia gouldi* zone) in Carter County, Okla.: at Rock Crossing of Hickory Creek, approximately center sec. 35, T. 5 S., R. 1 E., Criner Hills; NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E.; SE $\frac{1}{4}$ sec. 32, T. 2 S., R. 2 E., about 2 miles northeast of Springer.

Discussion.—*Skenidioides perfectus* is a small species suggesting *S. anthonen-sis*, *S. costatus*, *S. convexus*, and *S. rectangulatus*. The Oklahoma species dif-

fers from *S. anthonensis* in its more angular outline and stronger folding. It differs from *S. costatus* in the rib development, in having a less convex lateral profile than the Virginia form, and in having a stronger fold. The Oklahoma species differs from *S. convexus* in its less rounded lateral profile of the pedicle valve and its less deep sulcus. Resemblance to *S. rectangulatus* is quite strong, but the Virginia species has a broader sulcus, squarer outline, and more apsacline interarea.

SKENIDIODES PLATYS Cooper, new species

Plate 98, F, figures 28, 29

Shell fairly large for the genus, wider than long with the width about $1\frac{1}{2}$ times the length; cardinal extremities acute; sides rounded and obliquely directed toward the middle; anterior margin somewhat nasute; anterior commissure deeply sulcate. Costae narrowly rounded and with intercostal spaces about equal to the width of the costae; 10 or 11 costae on the flanks and 8 to 10 on the fold and sulcus.

Pedicle valve barely convex in lateral profile; anterior profile strongly convex and median region narrowly rounded. Fold wide, prominent, multicostate, moderately elevated, formed by a complicated fascicle consisting of an unbifurcated pair on the outside, another unbifurcated pair inside the previous two, and a median intercalation all occupying the posterior half. Median intercalated costa bifurcating near the middle; the other costae may or may not bifurcate near the margin. Flanks flat to gently convex; interarea long and apsacline.

Brachial valve nearly flat in the posterior half but bent toward the pedicle valve when viewed from the side; anterior profile nearly flat; sulcus deep, occupying about one-third the width at the front margin; flanks bounding sulcus gently convex; posterolateral areas gently convex. Brachial interior with narrow, shallow, and short notothyrial platform.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 3.8 | ? | 5.4 ? | 5.7 | 1.9 |
| Paratype (117083a) | ? | 2.7 | 3.4 | 3.8 | ? |

Types.—Holotype: 117084; figured paratype: 117083a.

Horizon and locality.—Little Oak formation in Alabama on the Bessemer Iron District (15') Quadrangle; 600 feet east of the intersection of the Cahaba Valley road with the Helena road, $\frac{1}{2}$ mile north of Pelham; 1 mile north of Pelham.

Discussion.—This species is characterized by its flattened profiles and shallow pedicle valve. The species resembles *S. halli* most but is more strongly costate and has a more prominent fold and sulcus as well as less convex profiles.

SKENIDIODES RECTANGULATUS Cooper, new species

Plate 98, B, figures 6-10

Shell of about medium size for the genus, wider than long, subrectangular in outline with cardinal extremities nearly a right angle, but acute nevertheless;

sides nearly straight, sloping slightly medially; anterolateral extremities somewhat broadly rounded; anterior margin gently rounded to faintly emarginate. Anterior commissure deeply and widely sulcate. Surface costate, costae narrowly rounded; intercostal spaces about equal to the width of the costae. Costae numbering about 24, with 10 in the broad sulcus and 3 marking the carinate part of the fold. Intercalation in 2 generations, 1 about a millimeter anterior to the beak and the other near midlength or somewhat anterior thereto.

Pedicle valve deep but only gently convex in lateral profile; anterior profile strongly convex and narrowly rounded in the middle; median region subcarinate; fold not clearly demarcated from the flanks but the median fascicle consisting of a bifurcated pair, and the intercalated swollen costa intercalated in the pair is slightly elevated. Flanks flattened; lateral slopes steep. Interarea long and strongly apsacline; beak prominent.

Brachial valve faintly convex in lateral profile and broadly and gently convex in anterior profile. Umbo sulcate; sulcus wide, deepening and widening anteriorly to occupy more than half the width at the front margin; flanks bounding sulcus perceptibly inflated, fairly narrow; posterolateral extremities gently concave.

Measurements in mm.—Holotype, length 3.8, brachial length 3.1, width 4.4, hinge width 4.8, thickness 2.3.

Types.—Holotype: 117085c; unfigured paratypes: 117085a,b.

Horizon and locality.—Oranda formation in Virginia: Along the railroad $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle; 0.6 mile west of Linnville Station, Broadway (15') Quadrangle.

Same horizon in Pennsylvania: 1 mile north of Guilford Springs, $2\frac{1}{2}$ miles southwest of Chambersburg, Chambersburg (15') Quadrangle.

Discussion.—This species is characterized by its squarish form, its cardinal extremities almost forming a right angle, broad and deep sulcus but broad and not strongly elevated fold. The species suggests *S. elongatus* to which it may actually be ancestral, but it does not have the extravagant development of that species. Its squarish outline will help to separate it from most of the other species described herein except *S. obtusus*. It differs from the latter in its wider hinge and stronger and more distant costae.

SKENIDIOIDES TRANSVERSUS Cooper, new species

Plate 98, C, figures 11-17

Shell large for the genus, width approximately twice the length; cardinal extremities acutely angular; sides gently rounded, sloping obliquely toward the middle; anterior margin nearly straight; anterior commissure sulcate; sulcus shallow. Surface costate, costae broad, rounded, low, and separated by narrow intercostal spaces. Costae numbering about 24.

Pedicle valve evenly and gently convex in lateral profile; anterior profile broadly and fairly strongly convex; umbonal and median region moderately swollen; fold inconspicuous, not elevated but forming the crest of the median swelling; costae on fold 4 in number, consisting of 2 lateral costae extending to

and meeting at the beak and an intercalated costa between the lateral 2 which bifurcates the branches extending to the anterior margin; flanks bounding fold gently swollen. Interarea long and strongly apsacline.

Brachial valve slightly convex in lateral profile; interior profile broadly and gently convex; umbo gently swollen; fold originating on the umbo, shallow and narrow; occupied by 3 costae. Tongue broad. Flanks bounding sulcus gently inflated; posterolateral areas flattened.

Interior of pedicle valve with small teeth and broad and shallow free spondylium; brachial valve with broad and shallow notothyrial cavity, long brachiophores, and prominent brachiophore plates.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 3.4 | ? | 5.3 | 6.4 | ? |
| Paratype (brachial valve 117086d) .. | ? | 2.8 | 5.3 | 5.9 | ? |

Types.—Holotype: 117086c; figured paratypes: 117086d,g; unfigured paratypes: 117086a,b,e,f,h,i.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species is characterized by its large size and transverse form. In these respects it differs from all others herein described. It is also characterized by having a low fold and a shallow sulcus. This combination of characters makes it unique.

SCAPHORTHIS Cooper, new genus

(Greek *scaphos*, hollow)

Subcircular to transversely subelliptical in outline; margins rounded; anterior commissure rectimarginate or sulcate; biconvex in profile, the pedicle valve having the greater convexity; brachial valve sulcate, sulcus usually shallow; hinge narrower than the greatest shell width which is at about the middle; surface multicostellate; test fibrous, impunctate.

Pedicle interior with open delthyrium or with delthyrium constricted slightly by lateral plates; delthyrial cavity deep; teeth small, sharp; fossettes moderately deep; dental plates short, flaring; muscle field orthoid in pattern, somewhat heart shaped in outline; diductor scars narrow; adductor track wide; anterior margin of muscle field slightly thickened and often with a low median callosity anterior to the anterior margin; vascula media divergent, many branched.

Brachial valve with deep but narrow delthyrial cavity; cardinal process with narrowly rounded shaft but thin and bladelike myophore; brachiophores short and stout but with fairly long, sharp points; brachiophores supported by stout plates that converge to the median ridge and unite with it; fulcral plates small; median ridge low, narrow, subcarinate, and extending to about the middle. Adductor field small, anterior scars separable into pairs.

Genotype.—*Scaphorthis virgininiensis* Cooper, new species.

Discussion.—This genus is characterized by its generally dalmanellid form but is distinguished from all members of that group by its impunctate shell. The genus is further characterized by the narrow notothyrial chamber enclosed by the supporting plates of the brachiophores. This latter structure is similar to that of *Mimella* and the Plectorthidae but differs in having the brachiophore supporting plates more erect and uniting with the median ridge at its posterior end. The genus is most closely related to *Corineorthis* Stubblefield described from the Ordovician of Cornwall, England. It differs from the British genus in its strongly biconvex valves. *Corineorthis* is characterized by having a concave pedicle valve.

A feature of considerable interest in this genus is the form of the brachiophores. These are divisible into two parts: a base and a "crus." The base is a short, thick plate supported by the brachiophore plates that unite with the median ridge. The "crus" is a short, delicate, and sharp point extending from the free end of the brachiophore.

SCAPHORTHIS KAYI Cooper, new species

Plate 55, D, figures 30-41

Corincorthis sp. COOPER and COOPER, Bull. Geol. Soc. Amer., vol. 57, p. 113, pl. 3, fig. 13, 1946.

Shell fairly large, subcircular in outline with the width slightly greater than the length. Hinge slightly narrower than the greatest shell width which is located at about the middle. Lateral and anterior margins broadly rounded. Surface multicostellate, costellae appearing in 5 generations. Costellae of first 4 generations of about equal size at the front but those of the fifth generation more slender than the rest. About 11 costellae in 5 mm. at the front margin of a valve 17 mm. long.

Pedicle valve moderately and unevenly convex in lateral profile with the maximum convexity located in the posterior half. Anterior profile a somewhat narrowly convex arch with steep sides. Beak forming an angle of about 140° , strongly incurved, elevated. Umbonal region convex and median portion of valve swollen; lateral slopes steep. Anterior slopes less steep than the lateral ones. Interarea long, strongly curved, nearly orthocline.

Brachial valve gently convex in lateral profile with the maximum convexity at about the middle; broadly and gently convex in anterior profile but with a pronounced flattening of the median part of the profile. Umbonal region slightly sulcate with the sulcus extending anterior to the front margin where it is very faint. Sulcus shallow and broad. Flanks narrow, slightly convex with gentle lateral slopes but with steeper slopes to the cardinal extremities. Interarea very short, anacline.

Pedicle interior with short, thick dental plates defining a narrow but deep delthyrial chamber. Muscle field elongate oval in outline, individual muscles difficult to differentiate. Vascula media short, subparallel; ovarian impressions small.

Brachial interior with brachiophore plates uniting with the median septum

to form a narrow but deep cruralium occupied by a slender, linear, ridgelike cardinal process. Median ridge reaching the middle of the valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 17.8 | 15.8 | 19.5 | 12.6 | 9.6 |
| Paratype (116907a)..... | 18.0 | 15.6 | 19.5 | 15.4 ? | 8.9 |
| " (116907b)..... | 15.8 ? | 14.2 | 17.8 | 11.6 | 7.0 |
| " (pedicle valve 116906a). . | 16.9 | ? | 18.5 | 12.7 | 4.5 |

Types.—Holotype: 111787; figured paratypes: 116905, 116906a, 116907a,d; unfigured paratypes: 116906b-d, 116907b,c,e-i.

Horizon and locality.—Shippensburg formation (Pinesburg member) in Pennsylvania on the Chambersburg (15') Quadrangle: $1\frac{3}{4}$ miles west of Kauffman; 0 to 50 feet above the Lowville in a field just north of the railroad cut 2 miles southwest of Marion Station.

Same formation in Maryland: In the shaly cobbly beds between the lower *Echinospaerites* zone and the first *Nidulites* zone on U. S. Highway 40, just west of the bridge over Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Edinburg formation (*Cyrtototella* zone) in Virginia: $\frac{3}{4}$ mile north-northeast of Glendale School, Winchester (15') Quadrangle; 1.5 miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle; 500 feet southeast of U. S. Highway 11, 1 mile northeast of Toms Brook, Strasburg (15') Quadrangle.

Discussion.—This species is the largest member of the genus so far known. It is abundant in the lower part of the Edinburg and Shippensburg formations. It differs from the other two known species in size, in having a nearly rectimarginate anterior commissure, and in having somewhat stronger costellae.

SCAPHORTHIS PERPLEXA Cooper, new species

Plate 55, B, figures 12-26

Dalmanella sp. BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 42, pl. 73, figs. 24, 25, 1942.

Corincorthis sp. COOPER and COOPER, Bull. Geol. Soc. Amer., vol. 57, p. 113, pl. 3, fig. 14, 1946.

Shell small, transversely subelliptical in outline. Hinge narrower than the maximum shell width which is located at the middle. Cardinal extremities obtuse. Sides narrowly rounded. Anterior margin broadly rounded. Surface costellate, costellae appearing in 4 generations, about 4 costellae in 1 mm. at the front of a valve $7\frac{1}{2}$ mm. long.

Pedicle valve evenly convex in lateral profile with the maximum convexity at about the middle. Anterior profile narrowly convex medially and with steep slopes. Beak incurved and extending posterior to the posterior margin. Umbo narrowly convex and merging with a longitudinal median elevation or fold, the narrow convexity of which decreases anteriorly. Flanks slightly concave and steep sided. Interarea moderately long, curved, nearly orthocline.

Brachial valve strongly convex in lateral profile with the maximum convexity in the posterior half. Anterior profile a broad, slightly elevated arch depressed

medially. Median sulcus originating at the beak and deepening anteriorly, shallow and very broadly U-shaped in section. Flanks bounding sulcus slightly swollen and with gentle slopes to the margins. Posterolateral slopes to the cardinal extremities are the steepest slopes. Anteriorly the sulcus produces a short, bluntly pointed tongue. Interarea short.

Pedicle valve interior with small teeth having small but deep fossettes. Dental plates short and flaring. Delthyrium wide but usually more or less narrowed by the growth of lateral (deltidial?) plates. Delthyrial cavity deep; muscle area somewhat heart shaped and extending a short distance anterior to the ends of the dental plates; a slight callosity at the anterior margin of the muscle field. Vascula media diverging widely from the diductor scars.

Brachial valve interior with a short, narrow but deep notothyrial cavity formed by the sides of the brachioophores and their supporting plates. Cardinal process a more or less well developed simple ridge. Brachioophores long and slender, bounding deep sockets defined by small fulcral plates. Brachioophores supported by short plates uniting with the floor of the notothyrial cavity and the median ridge. Anterior adductor impressions larger than the posterior pair and separated by a low median ridge that extends to the middle of the valve.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|-------------------------------|--------|-------|-------------|-----------|
| Holotype | 7.6 | 8.5 | 5.6 | 4.5 |
| Paratype (111802k)..... | 6.4 | 7.5 | 5.5 | 3.7 |
| “ (pedicle valve 111802m)... | 8.5 | 9.4 | 6.7 | 3.6 |
| “ (brachial valve 111802s)... | 8.0 | 10.9 | 7.5 | 1.5 |

Types.—Holotype: 111802c; figured paratypes: 111802d,k,l,r-u; unfigured paratypes: 111802a,b,e-j,m-q.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At the Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; Botetourt formation in Virginia: 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Discussion.—This is the smallest of the three species herein described. It is totally unlike *S. kayi* in size, ornamentation, and the moderately strong sulcation of the anterior commissure. It differs from *S. virginiensis* in being smaller and less robust, in having a more convex and subcarinate pedicle valve and finer costellae.

SCAPHORTHIS VIRGINIENSIS Cooper, new species

Plate 55, A, figures 1-11

Corineorthis sp. COOPER and COOPER, Bull. Geol. Soc. Amer., vol. 57, p. 113, pl. 3, fig. 15, 1946.

Shell fairly large, intermediate in size between *S. kayi* and *S. perplexa*; sub-circular in outline with well-rounded sides and anterior margin; anterior commissure rectimarginate; surface multicostellate, 2 to 3 narrowly rounded costellae in 1 mm at the front margin of a large adult.

Pedicle valve moderately convex in lateral profile with the greatest convexity

at about the middle; anterior profile narrowly convex in the midregion with long, flat, and steep slopes to the margins; anterior slope gently convex, long; beak somewhat elongated and protruding; umbo narrow, swollen, the swelling continuing to the middle; umbonal slopes steep. Interarea gently curved, apsacline; teeth small, pointed; fossettes deep; delthyrial cavity deep; dental plates short, divergent; umbonal cavities shallow; muscle field not deeply impressed, slightly thickened anteriorly.

Brachial valve moderately convex in lateral profile and with the greatest convexity in the posterior third; anterior profile broadly convex, indented medially, lateral slopes short, not steep. Fold originating at the umbo, widening anteriorly to the front margin where it is quite shallow; flanks bounding sulcus gently swollen; slopes to posterolateral areas gentle. Notothyrial cavity deep, cardinal process a low, simple ridge; median ridge moderately high; brachiophores long and slender; brachiophore supports slender and discrete, fulcral plates well defined.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve)..... | 10.5 | ? | 12.2 | 9.1 | 3.1 |
| Paratype (111788a)..... | 8.6 | 7.4 | 9.5 | 7.1 | 3.9 |
| " (pedicle valve 116903e)... | 11.2 | ? | 12.3 | 10.3 | 3.1 |
| " (" " 116903f)... | 9.7 | ? | 10.6 | 8.3 | 3.1 |
| " (brachial valve 111788c)... | ? | 10.1 | 12.7 | 10.2 | 2.1 |
| " (" " 116903d)... | ? | 9.0 | 11.2 | 9.3 | 1.6 |

Types.—Holotype: 116903c; figured paratypes: 111788a,c,e, 116903a,b,e; unfigured paratypes: 111788b,d, 116903c,d,f-i.

Horizon and locality.—Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—This species is intermediate in size between *S. kayi* and *S. perplexa* but differs strongly from both. From *S. kayi* it differs in having a more strongly sulcate brachial valve, and therefore a definitely sulcate anterior commissure. It differs from *S. perplexa* in being a more robust shell, in having a more elongate beak and longer interarea, and having somewhat stronger costellae.

SCAPHORTHIS sp. 1

Plate 55, C, figures 27-29

This is a large species as indicated by the four specimens available for study. These consist of a complete specimen, two brachial interiors, and part of a pedicle interior. The largest specimen is 10.8 mm. long and 13.0 mm. wide at the middle. This is not as large as *S. kayi* nor is the species as convex or as strongly costellate as *S. kayi*.

Figured specimen.—116908a.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

TROPIDOTHYRIS Cooper, new genus(Greek *tropis*, keel; *thyris*, opening)

Shell small to minute, subpentagonal in outline; hinge forming the widest part; sides oblique; anterior margin narrowly rounded; anterior commissure deeply sulcate; brachial tongue long and acute; surface smooth to more or less plicate, the plicae when present not always reaching the front margin. Impunctate.

Pedicle valve with long apsacline interarea and open delthyrium; teeth small; free spondylium deep and long.

Brachial valve with deep and narrow notothyrial cavity bounded by subparallel brachiophore plates attached to the valve floor; brachiophores long and slender; sockets defined by small fulcral plates; cardinal process long and slender, strongly elevated within the notothyrial cavity; median septum long and slender, strongly elevated at the anterior end to form a partition dividing the valves. Adductor impressions located on each side of the median septum.

Genotype.—*Tropidothyris pentagona* Cooper, new species.

Discussion.—This interesting little genus is undoubtedly related to *Skenidioides* and is probably a lateral branch of it. The resemblance is to be seen in outline and folding. Although a resemblance between the two genera is easy to see, nevertheless some important exterior differences occur in the ornamentation. The ornamentation of *Skenidioides* consists of narrowly rounded, usually direct or implanted costae; some specimens of *Tropidothyris* may be quite smooth. Others are marked by broad plications often indistinct and often not reaching the margins of the shell. Furthermore, although the folding and sulcation of the two genera are of the same type, those of *Tropidothyris* are much more strongly developed.

The interior of the valves of the two genera also show differences while at the same time showing close relationships. The free spondylium of the pedicle valve of *Tropidothyris* is usually deeper than that of *Skenidioides* probably because its valve is deeper and narrower. In the brachial valve the chief generic differences occur. In *Skenidioides* the notothyrial chamber is generally fairly wide and shallow and the brachiophore plates are attached to the median septum. When viewed from the anterior these plates are distinctly attached to the valve floor by callus or elevated above the floor. This is clearly the case in *S. billingsi* Schuchert and Cooper, the genotype. The brachiophore plates of *Tropidothyris* on the other hand, do not unite with the median septum but are attached to the floor of the valve. They make a subparallel thickening along the floor on each side of the shaft of the cardinal process, the anterior ends often swinging toward the median septum to close off the notothyrial cavity. The median septum and cardinal process are like those of *Skenidioides*.

This little genus is known only from the Pratt Ferry locality in Alabama.

TROPIDOTHYRIS PENTAGONA Cooper, new species

Plate 99, A, figures 1-14

Shell small, subpentagonal in outline and with the hinge forming the widest part; cardinal extremities acutely rounded; sides gently rounded, oblique; an-

terior margin narrowly rounded to nasute. Anterior commissure deeply sulcate; lateral commissure gently convex toward the pedicle valve in the posterior half but deeply concave toward the pedicle valve in the anterior half. Surface smooth or marked by 3 or 4 broad plications on the flanks; the plications may or may not reach the anterior margin.

Pedicle valve deep, gently convex in lateral profile but strongly carinate in anterior profile; umbo swollen and beak projecting beyond the posterior margin; umbo marked by a more or less prominent ridge or plication that may extend onto the fold; fold strongly elevated and prominent, becoming more and more elevated anteriorly; flanks gently swollen in the posterior half and separated from the fold by oblique, shallow depressions extending from the side of the fold to the anterolateral extremities. Sides of fold steep but only gently convex. Interarea long, curved, apsacline; beak pointed and incurved.

Brachial valve nearly flat in the posterior half in lateral profile, strongly bent toward the pedicle valve in the anterior half; anterior profile broadly and gently convex; umbonal and posterolateral areas flattened to faintly swollen; sulcus originating near the beak, shallow in the posterior third but widening and deepening rapidly in the anterior two-thirds; tongue long and bluntly pointed. Interarea short.

Interiors as described for the genus.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 1.93 | 1.60 | 2.0 | 2.26 | 1.3 |
| Paratype (117087b) | 1.68 | 1.42 | 1.93 | 2.00 | 1.4 |

Types.—Holotype: 117087a; figured paratypes: 117087b-e

Horizon and locality.—Pratt Ferry formation (lower 3 feet) in Alabama: 0.2 mile south of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species of this genus is known. The species is quite unlike any known species of *Skenidioides* in its smooth to plicate ornamentation and in the peculiar subpentagonal outline and exceptionally deep sulcus. Specimens are uncommon in the insoluble residue from the Pratt Ferry limestone.

PHRAGMORTHIS Cooper, new genus

(Greek *phragma*, fence)

Shell small, biconvex; valves of subequal depth; having the external appearance of a *Dalmanella* in the broad sense of the term. Anterior commissure sulcate. Surface multicostellate, some of the costellae swollen. Impunctate.

Pedicle valve with an elongate interarea and narrow, open delthyrium. Dental plates short, stout, receding. Muscle area with poorly defined scars; rounded in front, often thickened and elevated a little at the front and joined to the dental plates in such a way that the ensemble appears to be a sessile spondylium. Floor of the valve thickened for some distance anterior to the muscle field. Vascula media oblique, nearly straight.

Brachial valve with a deep but narrow notothyrial cavity. Brachiophores long and slender. Brachiophore supporting plates uniting with the median septum to form a cruralium. Socket plates well formed. Median septum extending to the anterior margin, slender and highest near the front. Septum nearly completely dividing the interior into 2 chambers. Cardinal process a low ridge on the floor of the cruralium not reaching the beak.

Genotype.—*Phragmorthis buttsi* Cooper, new species.

Discussion.—The combination of characters in this genus mark it as unique. *Phragmorthis* has some features of *Skenidioides* and *Mystrophora* but is unlike both of them internally although the exteriors are similar. Inside the pedicle valve the dental plates are short and receding. The teeth are small. The umbonal cavities between the shell wall and the dental plates are usually filled with shell material. The dental plates are usually revealed as short ridges developed on the under side of the palintrope along the delthyrial edge. These ridges extend to the floor of the valve at the apex of the delthyrial cavity and form its margins.

The muscle field of the pedicle valve is confined to the delthyrial cavity and is sufficiently thickened and washed onto the sides of the delthyrial cavity to make it appear that the dental plates and floor unite as a sessile spondylium. This is, however, a deception. Anterior to the muscle area a thickened patch, widest at its rear, extends and narrows anteriorly to reach a point not quite at the margin. On each side of this thickening appear the main branches of the pallial trunks which originate just outside and anterior to the point where the dental plates join the floor. No delthyrial plates of any sort were observed.

The interior of the brachial valve is even more remarkable than that of the pedicle valve. The notothyrial cavity is narrow but deep and its floor is formed by 2 concave plates that unite on their inner sides with the top of the median septum. On the outside they are joined to the delthyrial edge. The median line of the notothyrial chamber is occupied by the slightly raised upper edge of the median septum, but this does not reach the beak.

The sockets are very deep and are defined in the young by small socket plates. In adults the socket plates are buried by shell substance that fills in the hollows under the notothyrial cavity. The brachial processes are given off at the point where the notothyrial plates and delthyrial edge join. The brachial processes are long, fairly slender, and curved. On the outside they have a small thin elevated line which joins with the socket plate.

The most striking feature of this genus is the median septum which extends from the notothyrial cavity anteriorly to the front margin. It is highest at its front end where it forms a blunt point. As alluded to above, the septum is continued posteriorly as a ridge in the notothyrial cavity but does not reach the beak. This ridge undoubtedly serves as a cardinal process.

The adductor muscles were located on the floor of the valve on each side of the median septum. They form 2 elongate scars which may be elevated on elongated thickenings.

Close relationship of *Phragmorthis* to *Skenidioides* or *Skenidium* may be dismissed because those genera have an unsupported spondylium in the pedicle

valve. The structure of the brachial valve is also quite different in spite of the fact that both have a high median septum.

The closest similarity to *Phragmorthis* is to be seen in *Mystrophora* which is, however, a punctate genus. This genus also differs from *Phragmorthis* in having a plate in the delthyrium of the pedicle valve. In the brachial valve the two genera have similar septa, but the notothyrial cavity is shallower and more elevated on the septum than in *Phragmorthis*. Kayser describes the brachial processes as short whereas those of the Ordovician genus are very long.

PHRAGMORTHIS BUTTSI Cooper, new species

Plate 146, D, figures 31-38; plate 148, B, figures 5-11; plate 148, C, figures 12-26;
plate 221, C, figures 16-22

Shell small, wider than long, strongly biconvex, with an elongate interarea on the pedicle valve. Hinge slightly narrower than the width at the middle. Cardinal extremities obtuse. Lateral margin rounded; anterior margin indented medially. Anterior commissure sulcate. Surface ornamented by fine costellae, about 4 in 1 mm. at the front.

Pedicle valve moderately strongly convex in anterior and lateral profiles; front emarginate; valve swollen in the region from the beak to the anterior margin; lateral and posterolateral regions somewhat swollen. Midline of valve marked by a single costella stronger than the rest which extends from the beak to the indentation at the middle of the front margin and which serves as a fold. Concentric growth lamellae bent posteriorly at this strong costella.

Brachial valve strongly convex in lateral profile and with the greatest convexity at about the middle. Anterior profile bilobate. Valve divided into halves by a narrow groove extending from the beak to the anterior margin, this groove corresponding to the strong median costella of the pedicle valve. Flanks on each side of groove swollen. Lateral slopes moderately steep, and steeper than those to the median groove.

Measurements in mm.—Holotype, length 5.9, brachial length 5.0, width 6.8, hinge width 6.2, thickness 4.2.

Types.—Holotype: 116959m; figured paratypes: 116947a-c,h,i, 116959b,d, h,k,l, 116960a-e,h,k; unfigured paratypes: 116947d-g,j-l, 116958a-k, 116959a,c, e-g,i,j, 116960f,g,i,j.

Horizon and locality.—Effna-Rich Valley formations in Virginia: From Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles west of Harrisonburg, Harrisonburg (15') Quadrangle.

Arline formation in Tennessee: On north side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Pratt Ferry formation in Alabama: On the road 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is best recognized by its rotund valves, the elevated

median costella on the pedicle valve, and the deep, narrow sulcus on the brachial valve. The only other species like it are those of *Laticrura*, but in that genus the shell is punctate, the median ridge is low, and the sulcus of the brachial valve is never so deep as that of *Phragmorthis*.

This peculiar little shell occurs in abundance in the thin limestones above the large reef in the Porterfield Quarry, Va., and in the Pratt Ferry formation at Pratt Ferry, Ala. In both places the shells are silicified.

PHRAGMORTHIS CRASSA Cooper, new species

Plate 126, F, figures 30-35

Shell large for the genus, subquadrate in outline, wider than long; hinge narrow; cardinal extremities narrowly rounded; sides moderately rounded; anterior margin broadly rounded; anterior commissure narrowly sulcate. Surface multicostellate, costellae numbering about 45 and spaced about 2 to the millimeter at the front margin.

Pedicle valve gently and unevenly convex, the maximum convexity just anterior to the umbo and with the remainder of the valve flattened. Anterior profile subcarinate. Umbo narrowly convex, the convexity continued anteriorly as a low, narrow fold; flanks bounding fold flattened and descending fairly steeply to the lateral margins. Interarea long and steeply apsacline.

Brachial valve moderately convex in lateral profile and with the maximum convexity in the posterior third, the anterior two-thirds somewhat flattened. Anterior profile broadly and moderately convex; sulcus originating at the umbo and forming a narrow, steep-sided gash, widening only slightly in its passage to the anterior margin. Flanks bounding sulcus moderately swollen and with short, moderately steep lateral slopes. Beak strongly incurved and overhanging the interarea of the pedicle valve.

Measurements in mm.—Holotype, length 7.4, brachial length 7.2, midwidth 8.9, hinge width 6.2, thickness 4.0.

Type.—Holotype: 116963.

Horizon and locality.—Base of Martinsburg formation (part with *Brongniartella*=Salona formation) in Virginia: On Virginia County Road 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is characterized by the subcarinate pedicle valve and the deeply and narrowly sulcate brachial valve combined with the strong costellae. The latter are stronger than the costellae of *P. buttsi*. Furthermore, this species attains a larger size and is more deeply sulcate and carinate than the Pratt Ferry-Effna species.

Suborder CLITAMBONITOIDEA Öpik, 1934

Superfamily CLITAMBONITACEA Schuchert, 1929

Family TRITOECHIIDAE Ulrich and Cooper, 1936

Primitive Clitambonitacea with or without a spondylium but with perforate deltidium and chilidial plates; brachiophore supporting plates short, obscure.

Subfamily TRITOECHINAE Ulrich and Cooper, 1936

Tritoechiidae without a spondylium, the dental plates extending directly to the floor of the valve.

Genus TRITOECHIA Ulrich and Cooper, 1936

Tritoechia ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 624, 1936; Geol. Soc. Amer. Special Pap. 13, p. 160, 1938.

TRITOECHIA TYPICA (Ulrich)

Plate 77, A, figures 1-9

Deltatretra typica Ulrich in SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 206, pl. 6, figs. 10, 14, 19 (lectotype), 30, 1932.

Tritoechia typica (Ulrich) ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 169, pl. 33B, figs. 7-28, 1938.

Interior and exterior views of this genus and species are introduced for comparison with the rare genus *Eremotoechia*. From present knowledge the latter appears to be related to the common Lower Ordovician (Canadian) genus.

Types.—Lectotype: 91749c; paratypes: 91749a,b,d; hypotypes: 91750a-m; 92985a-l.

Horizon and locality.—Kindblade formation, Arbuckle Mountains, Okla.

Subfamily POLYTOECHINAE Öpik, 1934

Genus POLYTOECHIA Hall and Clarke, 1892

Polytoechia HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 239, 1892.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 175, 1938.

POLYTOECHIA ? OAKENSIS Butts

Polytoechia ? oakensis BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 116, pl. 26, figs. 25, 26, 1926.

This is a shell of uncertain generic affinities, which has never been described. It is known only from two pictures in Butts' report on Alabama geology. The specimen is small, measuring 8.7 mm. long, 9.4 mm. at the middle, which is the widest part, 7.2 mm. along the hinge, 5.7 mm. thick, and the brachial valve is 7.7 mm. long. The pedicle valve has a broad interarea which is steeply apsacline. The beak is slightly incurved. The delthyrium is open. The brachial valve is moderately convex in both profiles, and both valves show traces of fine radial ornament.

The valves are so heavily silicified that few pertinent details can be seen through the delthyrium. A thickening at the beak which forms a moderately deep V suggests the presence of a spondylium. No details of the brachial valve interior can be determined.

The general aspect of this shell suggests the genus *Polytoechia*, but no trace of a pseudodeltidium can be detected. The specimen also suggests Butts' *Polytoechia symmetrica* which Ulrich and Cooper (1938, p. 144) assigned to the genus

Finkelburgia. Actually *Polytoechia oakensis* is unlike any Little Oak species yet seen, and it is more like shells from the underlying Odenville formation. It is here suggested that *P. oakensis* was not derived from the Little Oak, and it is therefore not listed with that fauna.

EREMOTOECHIA Cooper, new genus

(Greek *eremos*, solitary; *toiros*, room)

Shell fairly large, valves of unequal depth and convexity, the brachial valve having the greater depth; hinge narrower than the greatest shell width. Anterior commissure uniplicate. Surface finely multicostellate.

Delthyrium of pedicle valve covered by a convex pseudodeltidium perforated by a foramen at its apical end. Interarea moderately long. Delthyrial cavity wide and shallow; dental plates short but strong, divergent. Teeth small; crural fossettes small.

Cardinalia suggesting the Canadian genus *Tritoechia*. Brachial umbo greatly swollen; brachiophores narrow rods supported by shell substance along the surface facing the brachial valve and the posterior inner wall. Median ridge rudimentary or obsolete. Cardinal process large, with a short shaft, but large lobate myophore. Chilidial plates small. Musculature indistinct.

Genotype.—*Eremotoechia claudi* Cooper, new species.

Discussion.—Externally this peculiar genus has the appearance of *Mimella* or a small *Hebertella* in the strongly convex brachial valve, the less convex pedicle valve, and the multicostellate ornamentation. However, the presence of a pseudodeltidium over the delthyrium, a feature not yet seen in *Hebertella* and its allies, serves to separate *Eremotoechia* from its homeomorphs.

The internal features of *Eremotoechia* are totally unlike those of the Hebertellids, but indicate relationship with *Tritoechia* and *Pomatotrema* of the upper part of the Canadian period. The pseudodeltidium of the pedicle valve is perforated by a small foramen. The internal features of the pedicle valve are so like those of the Tritoechiidae that this feature, too, probably conformed to the family characters. The dental plates of *Eremotoechia* are shorter and more flaring than is usual in *Tritoechia*, but this is probably caused by the lesser length of the palintrope.

The greatest similarity to *Tritoechia* may be seen in the brachial valve. On the exterior, one striking characteristic is preserved in the chilidial plates. Although these are small and not conspicuous, they are characteristic of the family. The beak and umbo of *Eremotoechia* are more arched and swollen than is usual in *Tritoechia*. For this reason the cardinal process has only a short, curved shaft which brings the myophore well beyond the level of the interarea. The myophore is strongly lobate, with the central lobe elevated, and the lateral lobes depressed. The brachiophores are mostly concealed by callus which spreads over the structures of the umbonal chamber. For this reason it is not possible to determine the presence or absence of the short and inconspicuous supporting plates of the Tritoechiidae.

EREMOTOECHIA ALABAMENSIS Cooper, new species

Plate 78, A, figures 1-9

Shell of about medium size for the genus, transversely and broadly elliptical in outline. Hinge narrower than the midwidth; cardinal extremities obtusely angular, valves subequal in depth; sides rounded, maximum width at the middle. Anterior margin broadly rounded, anterior commissure broadly uniplicate. Surface multicostellate, costellae unequal in size, crowded, with striae narrower than the width of the costellae; about 12 costellae in 5 mm. at the anterior margin.

Pedicle valve gently convex in lateral profile and with the maximum convexity at about the middle; anterior commissure broadly and gently convex, the median region gently humped and with long, gentle lateral slopes. Umbo narrowly convex, the convexity continued anteriorly for about two-thirds the length but then merging with the flattened sulcate area. Median region somewhat swollen. Sulcus poorly defined, forming a broad, flattened or depressed area on the median part of the anterior third. Lateral areas somewhat flattened and forming long, gentle slopes to the cardinal extremities. Interarea long, flat, strongly apsacline. Pseudodeltidium narrow; foramen small.

Brachial valve fairly evenly but only moderately convex in lateral profile; anterior profile broadly and fairly strongly convex. Umbonal region swollen; median region from umbo to anterior margin swollen; sulcus shallow and narrow, originating at the beak and extending to the middle where it disappears in the swelling anterior half which forms an ill-defined fold. Flanks full and with short, steep slopes to the margins and cardinal extremities. Chilidial plates prominent. Interior not known.

Measurements in mm.—Paratype (117060a), length 14.0, brachial length 13.7, width 18.6, hinge width 12.1, thickness 8.7.

Types.—Holotype: 117060b; figured paratype: 117060a; unfigured paratypes: 117060c-f.

Horizon and locality.—Little Oak formation in Alabama: From a road cut on U. S. Highway 31, $\frac{1}{2}$ mile north of Pelham, Bessemer Iron District (15') Quadrangle.

Discussion.—This species is a fairly large one. Fragments in the collection suggest a species comparable in size to *E. cloudi*. It is characterized by a short but fairly strong brachial sulcus and a corresponding short, low, and narrow fold on the opposite valve. In these respects it differs from *E. cloudi* and *E. silicica*. The little known about the latter species indicates a shell somewhat smaller than *E. alabamensis*.

EREMOTOECHIA CLOUDI Cooper, new species

Plate 77, B, C, figures 10-27

Shell moderately large, wider than long with the hinge equal to about three-fifths the greatest width which is at the middle. Cardinal extremities obtusely rounded. Lateral and anterior margins broadly rounded. Anterior commissure

broadly unisulcate. Surface multicostellate, with about 3 costellae occupying 1 mm.

Pedicle valve gently convex in lateral profile, with the strongest convexity in the posterior half; front half flattened. Anterior profile with the strongest convexity at the center and the lateral slopes flattened and gently inclined. Umbonal region somewhat swollen. Sulcus originating at the middle of the valve deepening and widening to the front margin, the sulcus producing a short, narrowly rounded tongue. Anterolateral flanks bounding the sulcus flat; slopes to cardinal extremities moderately steep, flat in profile.

Brachial valve evenly convex in lateral profile with the greatest convexity at the umbo; moderately strongly convex in anterior profile. Umbo swollen, protruding beyond the posterior hinge margin. Umbo depressed medially by a faint and narrow sulcus which disappears at the middle where a low but distinct fold originates and extends to the front margin. Flanks of shell steeply inclined. Slopes to cardinal extremities steep; cardinal extremities deflected. Interarea short, curved.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 19.0 | 18.5 | 22.4 | 16.6 | 12.5 |
| Paratype (117062) .. | 20.3 | 17.5 | 23.9 | 16.0 | 11.8 |

Types.—Holotype: 117061a; figured paratypes: 117061b, 117062.

Horizon and locality.—Arlene formation in Tennessee: $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 1 mile southeast of Fowlers Mill, 10 miles southeast of Loudon, Loudon (30') Quadrangle.

Discussion.—This, like all known species of *Eremotoechia*, is a very rare one. At the present writing only four specimens are known. These four specimens indicate this to be the largest species in size and the one with the strongest ornamentation. The species is further characterized by the disproportionate depth of the two valves, the brachial valve having the greater depth. The pedicle valve is characterized by its generally gentle convexity; the brachial valve is distinguished by its rounded contours and the inconspicuous sulcus and the indefinite anterior fold. This species differs from the other two known ones in its superior size, lack of pedicle folding, and modest development of the brachial sulcus.

EREMOTOECHIA SILICICA Cooper, new species

Plate 50, B, figure 7; plate 99, H, figures 47-52; plate 186, F, figures 20-25

Smaller than the preceding species; wider than long and having a subquadrate to subrectangular outline. Valves subequal in depth, the brachial valve having a slightly greater depth. Sides and anterior margin rounded; anterior commissure broadly and gently uniplicate. Surface multicostellate; costellae narrow and separated by spaces greater than the width of the costellae; about 3 costellae in 1 mm. at the front margin.

Pedicle valve unevenly convex in lateral profile, the median portion somewhat

narrowly rounded, while the anterior portion is flattened and bent toward the brachial valve and the posterior part is gently convex. Anterior profile forming a fairly strong arch with convex middle and long, strongly sloping sides. Umbonal region somewhat gently swollen; median region tumid, sloping steeply in all directions except that toward the umbo; interarea strongly apsacline, moderately long; foramen fairly large. Interior with small teeth having deep but small fossettes; dental plates well developed, divergent. Delthyrial cavity moderately deep; diductor tracks wide and direct, separated by 2 parallel thin, low ridges which form an adductor track.

Brachial valve in lateral profile moderately but unevenly convex, the greater convexity in the posterior half and with the anterior half flattened. Anterior profile strongly domed, the top of the dome somewhat flattened and the sides with steep but short slopes. Median region inflated and with steep slopes laterally and anteriorly; umbonal region somewhat inflated and marked by a short and shallow sulcus which disappears posterior to the middle; anteromedian region somewhat swollen to obliterate the sulcus but not forming a distinct fold. Interior with broad brachiophores and deep sockets; cardinal process with bulbous myophore; median ridge almost obsolete, and confined to the umbonal region.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | ? | 11.2 | 14.2 | 9.4 | 3.6 |
| Paratype (117065b)... | 10.4 | ? | 12.3 | 8.7 | 3.7 |
| " (117065c)... | ? | 8.9 | 12.2 | 8.8 | 3.5 |

Types.—Holotype: 117064a; figured paratypes: 117063, 117064b,c; 117065g, h,j,l,n; unfigured paratypes: 117064d,e, 117065a-f,i,k,m.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile south of Pratt Ferry, Blocton (15') Quadrangle.

Arline formation in Tennessee: About 100 yards south of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is based on adequate but possibly mostly young specimens. It is the only material that yields a clue as to the nature of the pedicle muscle field. The species as now defined differs from the other two known ones in its finer costellae, more convex pedicle valve, and more strongly convex profiles. A somewhat crushed complete specimen from the Negro Cemetery in Friendsville is assigned to this species because of its fine ornamentation.

Family CLITAMBONITIDAE Winchell and Schuchert, 1893

Clitambonitacea with radial ornamentation and spondylium simplex. With or without lateral plates or pseudodeltidium.

Subfamily ATELEASMATINAE Cooper, new subfamily

Clitambonitidae with or without lateral plates.

This subfamily is proposed to include *Apomatella* and *Atelelasma* which are

more primitive (or possibly more specialized) members of the family in not being provided with complete deltidial covers. *Apomatella* has an open delthyrium, and *Atelelasma* is distinguished by the presence of lateral plates that grow obliquely toward the center of the delthyrium.

Absence of modifying plates over the delthyrium among the Clitambonitacea may be a primitive character or it may be the reverse. Not enough is yet known of the development of these forms to be sure which is the correct view. Among the earliest of the Orthidae a deltidial cover is common, and its absence in the later members suggests specialization. In the instance of *Apomatella* and *Atelelasma*, which are stratigraphically early members of the family, absence of the covers may indicate primitive rather than specialized characters.

ATELELASMA Cooper, new genus

(Greek *ateleō*, imperfect; *elasma*, plate)

Planoconvex to unequally biconvex; hinge wide; interarea of pedicle valve long and generally flat; delthyrium modified by lateral plates only. Anterior commissure rectimarginate to gently sulcate; surface multicostellate, costellae often swollen and hollow. Impunctate.

Pedicle interior with broad spondylium simplex supported by a short septum. Vascula media usually strong and located on each side of the median septum.

Brachial valve interior with brachiophores in the form of thin, flat blades supported by swelling of the thick notothyrial platform. Cardinal process a simple septum. Chilidium prominent. Median ridge thick, elevated and extending to about the valve middle.

Genotype.—*Atelelasma perfectum* Cooper, new species.

Discussion.—This genus is characterized by its *Vellamo*-like form and usually open delthyrium which is only modified by erect lateral plates. In this respect it differs from all other members of the Clitambonitidae, which have a strong pseudodeltidium with large subapical foramen. It differs from *Apomatella* in having a higher organization, usually apsacline interarea, and a well-developed chilidium which is absent from the European genus. *Apomatella* has rudimentary lateral plates, but that genus is a more primitive one than *Atelelasma*.

Atelelasma differs from all members of the Estlandiidae in having an impunctate shell.

Schuchert and Cooper (1932, pl. 7, figs. 5 and 11) figure a specimen of *Atelelasma multicostum* (Hudson) having an imperforate, short pseudospondylium at the apex. This is the only specimen of the kind yet seen of this genus and the only occurrence of such a plate known in it. None of the silicified specimens prepared from the Arline formation showed any trace of such a plate. This pedicle plate is low and lies just under the edges of the palintrope. Other specimens of *A. multicostatum* are provided with lateral plates like those of the type species. This plate may be a pedicle attachment lost from the other known specimens as may be the case with certain spiriferoids, or it may be an atavistic occurrence, the importance of which is not yet understood.

ATELELASMA DECORTICATUM Cooper, new species

Plate 79, A, figures 1, 2; plate 82, J, figures 41, 42

Shell large, wider than long, hinge nearly equal in width to the width of the shell. Cardinal extremities nearly a right angle. Lateral margins nearly straight; anterior margin broadly curved to subtruncate. Surface multicostellate but the true nature of the costellae unknown.

Pedicle valve hemipyramidal; gently convex in lateral profile; strongly convex to subcarinate in anterior and posterior profiles. Median portion from beak to anterior margin swollen into a low fold from which the flanks of the shell descend steeply to the margins. Interarea moderately long and nearly procline. Delthyrium and lateral plates as usual in the genus.

Brachial valve nearly flat and with a shallow median sulcus extending from the beak to the anterior margin. Anterolateral extremities depressed; flanks bounding sulcus slightly swollen.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---------------------------------------|--------|--------|-------------|-----------|
| Holotype (pedicle valve)..... | 16.2 | 23.5 | 21.7 | 6.6 |
| Paratype (brachial valve 110112b).... | 18.4 | 22.6 ? | ? | ? |

Types.—Holotype: 110112a; unfigured paratypes: 110112b-d; figured specimens: 117010.

Horizon and locality.—Murat formation in Virginia: At Murat, Natural Bridge (15') Quadrangle, 1½ miles west of Lexington; 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Lincolnshire formation in Tennessee: On south side of the road opposite Shiloh Church, northwest subquad., Pressmens Home (T.V.A. 171-NE) Quadrangle.

Lincolnshire (or Whistle Creek) formation in Virginia: At the top of the ridge 1,000 feet north of the road on Buffalo Creek, 2½ miles west of Murat, Natural Bridge (15') Quadrangle (specimen doubtfully placed in this species).

Lincolnshire formation (with *Sowerbyites*) in Virginia: At the spring ¼ mile east of the junction of Virginia Highways 608 and 652, 6 miles southeast of Staunton, Augusta County.

Discussion.—As here defined this species may include some specimens that will ultimately have to be excluded both on biological and on stratigraphic grounds. The ornamentation of the specimens taken from the Murat limestone is poorly preserved, while the exteriors of all the other specimens taken from this horizon are not well preserved. The specimens from Buffalo Creek may actually have been derived from the Whistle Creek limestone and may be referable to a totally different species when better specimens are found.

The examples taken from the Murat calcarenite are all large, generally larger than most of the other described species except *A. perfectum*. It differs from the latter in its more transverse form and less convex pedicle valve.

ATELELASMA DORSOCONVEXUM Cooper, new species

Plate 80, G, figures 35-39; plate 82, M, figures 53-57

Of about medium size for the genus, length-width relation variable; cardinal extremities nearly a right angle; sides gently rounded; anterior margin broadly rounded. Surface multicostellate with about 2 costellae in a millimeter at the front margin.

Pedicle valve hemipyramidal with a moderately long interarea inclined in a catacline or strongly apsacline position. Lateral profile very slightly convex. Interior with spondylium short and shallow, septum unusually short. Pallial impressions not strongly impressed.

Brachial valve gently convex in lateral profile with the maximum convexity in the posterior half. Median sulcus shallow and narrow but extending from the umbo to the middle. Flanks gently convex. Interior with notothyrial platform not strongly thickened; median ridge low and slender and extending nearly to the middle; cardinal process slender.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width |
|--|--------|--------------------|-------|----------------|
| Holotype (pedicle valve) | 15.1 | ? | 17.7 | 15.8 |
| Paratype (pedicle valve 117011d) | 15.8 | ? | 15.7 | 14.0 |
| “ (brachial valve 117011e) | ? | 14.2 | 17.9 | 14.0 |
| “ (“ “ 117011f) | ? | 12.3 | 16.9 | 13.1 |

Types.—Holotype: 117011h; figured paratypes: 110128b, 110129a-d, 117011b, d-f; unfigured paratypes: 110128a,c,d, 117011a,c,g,i,j.

Horizon and locality.—Basal Athens formation in Tennessee: 2½ miles south-east of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle; 600 feet S. 40° E. of the railroad intersection with the highway 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-NE) Quadrangle.

Discussion.—This species differs from *A. perfectum* in its smaller size, relatively greater width to length, shallower and shorter spondylium, more strongly sulcate and more convex brachial valve, and finely costellate exterior. Most of the specimens come from leached limestone taken from the road and bank near the intersection 2½ miles southeast of Riceville. The specimens all occur in the form of impressions of the interior and exterior in a rock that is difficult to harden. Consequently, no replicas of the interior and exterior surfaces were prepared. The fairly strongly convex brachial valve seems to be a very characteristic feature of the species.

Pallial marks are fairly well displayed in the specimens figured, but those of the pedicle valve are not as well developed as those of the opposite valve. The pedicle vascula media are not long. This is a consequence, no doubt, of the very short median septum supporting the spondylium. The brachial valve shows 2 wide pallial trunks originating at the inside anterior of the adductor field.

ATELELASMA HOLSTONI (Hall and Clarke)

Orthis ? holstoni Safford in HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 218, 340, pl. 5A, figs. 35-37, 1892. For additional synonymy, see BASSLER, U. S. Nat. Mus. Bull. 92, p. 892, 1915.

Type.—Holotype: New York State Mus. 7922/1.

Horizon and locality.—Probably Hogskin member or Arline formation, vicinity of Knoxville, Tenn.

Discussion.—The description of this species is in such general terms and the stratigraphic horizon is so uncertain that it was not possible to identify any of the species recorded herein with it. Hall and Clarke record the horizon and locality as "Glade limestone" (Lebanon) from near Nashville. This is certainly a mistake, and the Bassler correction to the vicinity of Knoxville is probably more nearly correct. The formation from which the specimen came is possibly Arline but is more probably the Hogskin member.

ATELELASMA ? MULTICOSTUM (Hudson)

Plate 80, F, figures 26-34

Syntrophia multicosta HUDSON, New York State Mus. Bull. 80, p. 285, pl. 5, figs. 8-15, 1903.

Clitambonites multicostus (Hudson) RAYMOND, Ann. Carnegie Mus., vol. 7, p. 247, fig. 23; pl. 36, figs. 10-14, 1911.

aff. *Vellamo multicosta* (Hudson) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, pl. 7, figs. 5, 8-11, 1932.

Types.—Figured hypotypes: 110117a-d; A.M.N.H. 25048/1,3; Y.P.M. S359.

Horizon and locality.—Crown Point formation in New York on Plattsburg (15') Quadrangle: Valcour Island, Plattsburg.

Same formation in Vermont: On Isle La Motte, Rouses Point (15') Quadrangle.

Discussion.—This little species was once found in abundance on Valcour Island. Here the specimens were taken in the form of loose shells entirely free of matrix. Specimens in the National Collection show a trace of the plates along the sides of the delthyrium which are so characteristic of *Atelelasma*. A single specimen in the Yale Peabody Museum collection (catalog number S359) shows a small imperforate vestigial pseudodeltidium at the apex. This feature was not seen on any other specimens of *Atelelasma* including the superb silicified specimens from Friendsville. This pseudodeltidium is very much like that seen in *Kullervo punctata*.

ATELELASMA OBSCURUM Cooper, new species

Plate 78, D, figures 21-31

Fairly large for the genus, wider than long and with the greatest width at the hinge; cardinal extremities acute; sides sloping medially; anterior commissure rectimarginate. Surface multicostellate, costellae narrowly rounded with interspaces about equal in width to the width of the costellae; costellae numbering

about 7 in the space of 5 mm. at the front margin; a few costellae may be larger than the surrounding ones.

Pedicle valve hemiconical in lateral profile; anterior profile broadly triangular. Median region somewhat swollen; lateral areas with long, moderately steep slopes; interarea catacline, long; plates bounding delthyrium moderately high. Spondylium wide and shallow; median septum moderately long.

Brachial valve nearly flat to gently convex in lateral profile; same in anterior profile; umbo sulcate; sulcus shallow, widening to the front margin. Flanks bounding sulcus gently swollen; cardinal extremities deflected slightly toward the pedicle valve; chilidium small; notothyrial platform thick, cardinal process thin; median ridge reaching the middle; pallial marks moderately well developed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 15.3 | ? | 22.0 | 23.5 | 5.8 |
| Paratype (brachial valve 117012a) .. | ? | 15.7 | 22.3 | 20.3 | 3.4 ? |

Types.—Holotype: 117012d; figured paratypes: 117012a-c,e,f,i; unfigured paratypes: 117012g,h,j.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 0.4 mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; Republic Marble Quarry near Luttrell; south side of the school just north of the railroad crossing at Chesney, Luttrell (T.V.A. 155-NW) Quadrangle.

Discussion.—This is not a common species. It is suggestive of *A. perfectum* in its ornamentation but differs in its proportions; it is a much wider shell with a flatter brachial valve. None of the localities has yet yielded a specimen with both valves in contact.

ATELELASMA OKLAHOMENSE Cooper, new species

Plate 80, C, figures 12-19

Of about medium size for the genus, wider than long, with acute cardinal extremities and the hinge forming the widest part. Pedicle valve hemipyramidal with a broad, flat, and procline interarea. Beak pointed and slightly upturned. Brachial valve nearly flat with posterior portion extending well beyond the pedicle interarea, exposing the cardinalia to view. Surface marked by strong costellae separated by furrows narrower than the costellae. Costellae crossed by strong concentric fila. About 9 costellae in the space of 9 mm. at the front margin.

Margin of delthyrium bordered by low plates set obliquely on the delthyrial edge and decreasing to disappearance toward the beak. Spondylium fairly short. Chilidium short and appearing as a broad arch over a thin cardinal process.

Measurements in mm.—Holotype, length 10.8, hinge width 16.3, length of pedicle valve 8.9.

Types.—Holotype: 110124; figured paratype: 110125.

Horizon and locality.—Bromide formation (Mountain Lake member—near top

in *Multicostella convexa* zone) in Carter County, Okla.: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills.

Bromide formation (Mountain Lake member—bed 16 of Decker) in Johnston County, Okla.: On west branch of Sycamore Creek, sec. 22 and 27, T. 3 S., R. 4 E., 7 miles northwest of Ravia.

Discussion.—Up to the present time only two specimens have been collected. This species is characterized by its strong costellae constituting an ornamentation unlike any other species of comparable size. Interrupted fila give the costellae a spiny appearance. This is suggestive of *A. platys*, but that is a much smaller form.

ATELELASMA PERFECTUM Cooper, new species

Plate 79, B, C, figures 3-25; plate 126, H, figures 41-45

Shell large, having general appearance of *Vellamo*; unequally biconvex. Outline subquadrate. Lateral margins straight; anterior margin broadly curved to subtruncate. Anterior commissure gently sulcate. Ornamentation variable, consisting generally of costellae of unequal size. Stronger costellae extend from the beak to the anterior margin and separate 1 or more finer costellae.

Pedicle valve hemipyramidal; gently convex in lateral profile; more strongly convex in anterior profile. Lateral slopes steep; steepest on the descent to the cardinal extremities. Interarea long, strongly apsacline, gently curved or flat. Delthyrium wide; modified by lateral plates. Spondylium variable in form, low, shallow; narrow or broadly rounded at the front end. Median septum variable.

Brachial valve evenly and gently convex in lateral profile; median sulcus narrow, shallow, widening anteriorly, never conspicuous and becoming shallower at the front. Flanks slightly swollen. Region about cardinal extremities slightly depressed. Median ridge carinate, long. Cardinal process a simple ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 19.7 | 16.9 | 20.0 | 17.0 | 10.0 |
| Paratype (110135m) | 21.5 | 17.8 | 19.4 | 17.9 | 10.8 |
| “ (117014a) | 15.3 | 14.1 | 16.5 | 16.3 | 10.4 |

Types.—Holotype: 110135g; figured paratypes: 110135d,f,h-l,n,p, 110136, 117014a; unfigured paratypes: 110135a-c,e,m,o,q,r; figured specimen: 110132a.

Horizon and locality.—Arline formation in Tennessee: Along wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 1 mile northeast of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle; 1 mile southeast of Fowlers Mill, 10 miles southeast of Loudon, Loudon County; Chapman Highway, $2\frac{1}{2}$ miles southeast of south end Henley Street Bridge, Knoxville, Knoxville (T.V.A. 147-NW) Quadrangle; McMullens, Meadow (T.V.A. 139-NW) Quadrangle.

Doubtfully in Whistle Creek formation in Virginia: Top of ridge 1,000 feet north of the road on Buffalo Creek, $2\frac{1}{2}$ miles west of Murat, Natural Bridge (15') Quadrangle.

Discussion.—*Atelelasma perfectum* occurs in abundance in the beds containing *Christiania* at Friendsville and vicinity. The species is characterized by its large size, the moderately convex pedicle valve, and the gently convex, rather than flat, brachial valve. At Friendsville specimens are nicely silicified and can be developed for interiors.

The species is also characterized by its somewhat square form which distinguishes it from *A. decorticatedum* and *A. obscurum*.

ATELELASMA PLANUM Cooper, new species

Plate 80, D, figures 20-24

Shell small, plano- to concavo-convex; hemipyramidal in outline. Hinge slightly narrower than the greatest width. Cardinal extremities auriculate. Lateral margins nearly straight or sloping medially; anterior margin broadly rounded. Anterior commissure slightly sulcate. Surface multicostellate; costellae appearing in 4 generations by implantation. First generation forming strongest costellae which stand above the others; subsequent costellae tending to form fascicles with 2 or 3 generations in a fascicle.

Pedicle valve hemipyramidal; very gently convex in profile. Slopes to lateral and anterior margins steep; interarea long, procline. Delthyrium wide.

Brachial valve flat or gently concave, with a deep median sulcus originating at the umbo and extending to the front margin where it occupies about one-third the width. Flanks bounding sulcus slightly convex; anterolateral extremities slightly depressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.8 | 9.4 | 12.0 | 13.4 | 6.0 |
| Paratype (110142a) .. | 9.3 | 9.4 | 13.5 | 13.4 | 4.9 |

Types.—Holotype: 110142b; figured paratype: 110142a.

Horizon and locality.—Benbolt formation (?) in Tennessee: 1½ miles south-east of Knoxville, Knoxville (T.V.A. 147-NW) Quadrangle.

Discussion.—This species is characterized by its small size and the nearly flat brachial valve. In these respects it is like *A.?* *multicostum* and *A. platys*, but it differs from both of them in details of its ornamentation. The costellae of the former species are fine and even, whereas those of *A. plana* are differentiated into coarser and finer ones. The ornamentation of *A. platys* is characterized by spinelike projections along the costellae like those of *A. oklahomense*, but they are absent from *A. plana*.

ATELELASMA PLATYS Cooper, new species

Plate 50, G, figures 29-34

Shell small for the genus, wider than long with the hinge forming the widest part; sides sloping toward the middle; anterior margin broadly rounded; an-

terior commissure rectimarginate; costellae broad in early generations; 1 in 1 mm. at the front margin; concentric fila strong.

Pedicle valve unevenly convex in lateral profile, the posterior half gently convex, the anterior half depressed; anterior profile broadly triangular; median and lateral regions moderately swollen. Interarea long, strongly apsacline; spondylium wide and shallow; median septum short.

Brachial valve unevenly convex in lateral profile, the posterior half gently concave, the anterior half gently convex; anterior profile broadly and gently convex; sulcus originating at the beak and extending to the anterior margin, narrow and moderately deep throughout its length. Umbo swollen; region anterior to umbo concave; anterolateral areas bounding sulcus moderately convex; posterolateral areas gently concave; notothyrial platform broad; cardinal process thin; median ridge fairly long.

Measurements in mm.—Holotype, length 7.8, brachial length 7.3, width 10.6, hinge width 9.8+, thickness ca. 5.7.

Types.—Holotype: 110144.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: On the Maynardville Pike, 1.7 miles northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle.

Discussion.—This species is small and has a nearly flat brachial valve, thus suggesting such species as *A. ? multicotum* and *A. oklahomense*. It differs from the former in having stronger and more distant costellae; from the latter, which it resembles in having spiny projections on the costellae, it differs in being a much smaller shell and having a different outline. This species also differs from *A. variabile* in outline and ornamentation.

ATELELASMA SULCATUM Cooper, new species

Plate 81, B, figures 7-13

Shell of about the usual size for the genus, wider than long; hinge slightly wider than the midwidth; cardinal extremities slightly auriculate; sides nearly straight, sloping slightly medially; anterolateral extremities somewhat narrowly rounded; anterior margin nearly straight; anterior commissure rectimarginate; subequally costellate, about 10 costellae in 5 mm. at the front margin.

Pedicle valve with uneven lateral profile, the posterior half gently convex but the anterior half flattened. Anterior profile broadly triangular, the sides of the triangle with long, moderately steep slopes; median region slightly swollen; sides with long, gentle slopes; posterolateral region slightly sulcate just anterior to the posterior margin; interarea long, slightly procline. Spondylium narrow and moderately deep.

Brachial valve moderately convex in lateral profile; anterior profile broadly and gently convex but median region sulcate; median region swollen; umbo sulcate; sulcus narrow and shallow at the beak, widening and deepening anteriorly to the middle of the valve, becoming less deep from there to the anterior margin.

Flanks bounding sulcus swollen; posterolateral slopes short and steep. Median ridge long; notothyrial platform moderately wide.

Measurements in mm.—Holotype, length 13.5, brachial length 14.3, width 18.8, hinge width 20.7, thickness 9.0.

Types.—Holotype: 117013.

Horizon and locality.—Tulip Creek formation in Carter County, Okla.: 152 feet above the top of the basal sand on the first creek east of U.S. Highway 77, SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County; 3 miles north-northeast of Springer, SE $\frac{1}{4}$ sec. 32, T. 2 S., R. 2 E.

Discussion.—This is a very rare species; three specimens only have been found. One complete, beautifully preserved specimen furnished the details of the exterior. Two poorly preserved specimens showing the interior of both valves yielded some idea of the interior. The species is characterized by large size, rectangular outline, somewhat compressed form, convex brachial valve, and fairly strong median sulcus. It differs from *A. perfectum* in its proportions which are more widely rectangular than subquadrate. It differs from *A. obscurum* in the details of its ornamentation, which is much finer, and in its more convex brachial valve. It is quite unlike *A. oklahomense* in outline, profile, and ornamentation.

ATELELASMA VARIABLE Cooper, new species

Plate 81, A, figures 1-6; plate 82, K, figures 43-47; plate 82, L, figures 48-52

Shell small for the genus, variable in outline, wider than long, nearly square in large specimens with the hinge slightly wider than the midwidth; sides sloping gently toward the middle; anterior margin varying from broadly rounded to gently emarginate. Anterior commissure rectimarginate. Costellae variable, crowded, and separated by spaces narrower than the width of the costellae; 2 to 3 costellae occupy the space of 1 mm. at the anterior margin.

Pedicle valve gently convex in lateral profile; anterior profile broadly triangular; median region somewhat flattened; lateral areas somewhat rounded; posterolateral extremities deflected toward the brachial valve. Interarea long, strongly apsacline to catacline.

Brachial valve faintly convex to flat in lateral profile; anterior profile very slightly convex; umbo sulcate; sulcus shallow, widening anteriorly to the front margin, deepest in the median region and becoming shallower at the front margin. Flanks bounding sulcus moderately swollen; posterolateral extremities depressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 6.8 | 7.3 | 9.7 | 9.9 | 5.0 |
| Paratype (117015b).... | 9.7 | 9.7 | 11.7 | ? | 6.0 |
| “ (117015c).... | 5.8 | 6.3 | 8.5 | ? | 3.8 |

Types.—Holotype: 117015d; figured paratype: 117015c; unfigured paratypes: 117015a,b; figured specimen: 117996.

Horizon and locality.—Lenoir formation in Tennessee: From calcarenites under the Mosheim limestone, southwest side of cemetery behind the Quaker Church, north corner of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This is a rare species found only in a thin band of shale in the calcarenites behind the Quaker Church in Friendsville. The few specimens obtained show a variable form which is suggestive of the Crown Point species, *A. ? multicostum*. It differs from that form in its stronger ornamentation and the squarer form in the adult. Its outline and small size as well as its fairly uniform ornamentation distinguish it from *A. plana*.

ATELELASMA sp. 1

Plate 80, E, figure 25

Single pedicle valve placed under this name differs from *A. perfectum* by its less convex profile, more uniform costellae, and shallower and broader spondylium. This species differs from *A. decorticatum* by its lesser depth and apsacline interarea.

Measurements in mm.—110141, length 14, width 18, thickness 4.5.

Figured specimen.—110141.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile east of Cobb City=Cobb, Glencoe ($7\frac{1}{2}'$) Quadrangle.

ATELELASMA sp. 2

Plate 81, C, figure 14

An interior of a pedicle and brachial valve were taken from the Botetourt limestone on the roadside at the junction of Virginia Highways 114 and 311, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle, Virginia. The interiors resemble those of *A. obscura*, but nothing is known of the exterior; consequently, no further identification can be made.

Figured specimen.—117016.

Family KULLERVOIDAE Öpik, 1934

Vellamo-like Clitambonitacea with spondylium triplex and hemisyrix.

In Öpik's discussion of this family and genus it is stated that the shell substance of *Kullervo* is pseudopunctate. The specimens from the Southern Appalachians described herein are silicified, and the true structure of the shell is difficult to ascertain. However, silicified specimens of the Strophomenidae usually reveal the papillose surface clearly. No evidence of pseudopunctae was seen in the Appalachian specimens. It is thus possible that a parallel series of genera occurs in the United States that duplicates the structure of *Kullervo* but is impunctate. The pseudopunctate *Kullervo* should be assigned to the Strophomenoidea in the writer's opinion, but in the absence of good collections for study it seems best at present to leave the family in the Clitambonitacea.

Genus KULLERVO *Öpik*

Kullervo *Öpik*, Acta et Comment. Univ. Tartu, ser. A, vol. 23, No. 3, p. 70, 1932; idem, ser. A, vol. 26, No. 3, p. 162, 1934.

KULLERVO ORNATA Cooper, new species

Plate 80, A, figures 1-6

Shell small, wider than long with hemipyramidal pedicle valve. Surface multicostellate, the costellae crossed by elevated concentric plaits (lamellae). On the brachial valve the posterolateral areas are conspicuously marked by the concentric lines. Pedicle valve with broad shallow sulcus extending from beak to anterior margin; flanks rounded. Areas between flanks and posterior margin concave. Spondylium broad and shallow with the characteristic median depression flanked by narrow, elevated tracks. Median septum short.

Brachial valve slightly concave in the posterior half but slightly convex in the anterior half. Sulcus widening rapidly from the beak to the anterior margin where it occupies about one-third the width. Anterolateral flanks gently convex; posterolateral areas flattened. Brachial interior with strong anteriorly widening median ridge corresponding to the sulcus. Median ridge much elevated and thickened anteriorly. Cardinalia much thickened.

Measurements in mm.—Holotype, length 2.3, width 3.8, hinge width 4.5, thickness 2.6.

Types.—Holotype: 110150a; figured paratype: 110150b; unfigured paratype: 110150c.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species occurs with *K. parva* but is easily distinguished by the differences in profile and ornamentation. The brachial valve of *K. ornata* is concave in the posterior half but slightly convex in the anterior half and gives the impression of a nearly flat valve, while the brachial valve of *K. parva* is convex. The ornamentation of the latter consists of costellae of unequal size but with subordinate concentric ornament. On the other hand *K. ornata* has strong concentric ornamentation as well as costellae, and on the brachial valve the concentric ornamentation dominates the posterolateral areas.

KULLERVO PARVA Cooper, new species

Plate 80, B, figures 7-11

Small, the largest specimen in the collection attaining a width of slightly more than $\frac{1}{4}$ inch. Wider than long with acute cardinal extremities in the adult, but in young specimens the extremities are drawn into sharp ears. Pedicle valve hemipyramidal in lateral profile with a fairly prominent median sulcus extending from the beak to the anterior margin. Flanks bounding the sulcus narrowly rounded and the area to the cardinal extremities slightly concave. Spondylium large and shallow with a fairly deep median groove bordered by flat shelves on

either side. Median septum short. Pseudodeltidium appearing as a vestige of that plate at the apex.

Brachial valve convex in lateral profile and broadly convex in anterior profile. Sulcus deep, extending from the beak to the anterior margin and drawn into a short tongue anteriorly in the direction of the pedicle valve. Flanks bounding sulcus moderately convex with steep slopes to the posterolateral extremities but with more gentle anterior slopes. Cardinalia ponderous. Brachiophores widely divergent and supported by thick lateral swellings of callus. Cardinal process a simple ridge.

Exterior of both valves marked by narrowly rounded costellae.

Measurements in mm.—Holotype (brachial valve), length 4.8, width 7.5.

Types.—Holotype: 110148a; figured paratypes: 110148b, 110149; unfigured paratype: 110148c.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle.

Discussion.—This species can be readily distinguished from *K. ornata* with which it occurs by its convex brachial valve and predominantly radial ornamentation.

KULLERVO PUNCTATA Cooper, new species

Plate 99, G, figures 43-46

Shell fairly large for the genus, hinge forming the widest part; shell thick; surface costellate and filate, the two of nearly equal strength so that the intersection produces deep pits, arranged in radial and concentric rows.

Pedicle valve moderately convex in profile; moderately full in median and lateral regions. Interarea long; spondylium wide and moderately deep, the characteristic three tracks well developed. Median track deep; lateral tracks slightly overhanging the median one. Median septum moderately long.

Brachial valve gently convex in both profiles; interior with ponderous notothyrial platform, thick and long median ridge and long brachiophores.

Measurements in mm.—

| | Length | Midwidth | Hinge width |
|--|--------|----------|-------------|
| Holotype (pedicle valve) | 6.7 | ? | 6.6 |
| Paratype (brachial valve 117018b)..... | 3.3 | 5.8 | ? |

Types.—Holotype: 117018a; figured paratypes: 117018b,c.

Horizon and locality.—Botetourt ? formation in Virginia: On the south side of the paved road 0.2 mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Discussion.—This species is larger than the other described forms from lower Middle Ordovician rocks and is distinguished from them by the punctated appearance of the exterior.

KULLERVO SULCATA Cooper, new species

Plate 99, B, figures 15-18

Known from pedicle valve only. Minute, hemipyramidal as usual in the genus, strongly suggestive of *K. ornata* but differing in having a much deeper median sulcus, bounded by a strongly elevated costella. Outside each bounding costella and inside the posterior margin is a fascicle of 3 or 4 costellae. Area between fascicle and posterior margin concave and marked by strong, elevated concentric lines. Spondylium broad and shallow; septum short.

Measurements in mm.—Holotype, length 2.4, hinge width 3.9.

Type.—Holotype: 117017.

Horizon and locality.—About 3 feet above the base of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Superfamily TRIPLESIACEA Cooper, 1944

Impunctate brachiopods having a flat pseudodeltidium, small apical foramen in the pedicle valve, brachial valve with a long, forked cardinal process.

Family TRIPLESIIDAE Quenstedt, 1931

Characters same as those for the superfamily.

This family makes its first appearance in the Table Head series in the form of *Onychoplecia*. The small size and generalized form of these little shells are in keeping with the characters of an early stock. At the present time it is not possible to suggest a possible progenitor. The family and superfamily characters are all clearly developed in the earliest genus, but no indication is given by that form of primitive characters that might relate it to brachiopods of the early Ordovician.

ONYCHOPLECIA Cooper, new genus(Greek *onychos*, claw; *plekos*, plaited)

Shell small, tear-shaped in outline, narrowly lenticular in profile; valves unequally convex, the brachial valve having the greater depth. Anterior commissure uniplicate; fold of brachial valve usually short and in some species indistinct. Surface marked by concentric lines of growth only. Shell substance fibrous, impunctate.

Pedicle valve tear-shaped in outline, often with the beak elongated and slender; profile gently convex; delthyrium covered by a flat pseudodeltidium marked along its center line by a more or less narrow fold; foramen apical, small; interior marked by long, diverging dental plates; other details not known.

Brachial valve subcircular in outline and strongly convex in profile; chilidium small, elongate, subtriangular; cardinal process with stout shaft, forked distally, the prongs of the fork bearing the myophores. Other details of the interior unknown.

Genotype.—*Onychoplecia brevirostris* Cooper, new species.

Discussion.—Members of this genus are fairly common at a few places where early Middle Ordovician rocks are exposed. Generally these specimens have been placed in the genus *Camerella*. Examination of the pedicle beak region and confirmation of the presence of divergent dental plates definitely rules out relationship to the camerellids. The entire structure of this genus places it as the earliest known member of the Triplesiidae.

Triplesid characters appear in the pedicle valve in the form of the characteristic pseudodeltidium. This is a nearly flat plate narrowly folded in the middle. This narrow fold appears to be produced by anterior forward growth of the pseudodeltidium over the small triangular chilidium that overlies the shaft of the cardinal process. A few specimens only have revealed the presence of a small foramen at the apex. This may be elongated along the umbo by resorption as has been shown for other triplesids.

The brachial interior of most of the species described herein has been proved to possess the forked cardinal process of the Triplesiidae. In addition to the cardinal process several of the species revealed a small triangular chilidium like that described for *Onychotreta*.

The appearance and characters of this genus place it closest to *Triplesia*, and in common with that genus it is smooth and uniplicate. It differs from *Triplesia* generally in its smaller size, usually disproportionate depth of valves, the brachial valve being several times deeper than the pedicle valve, the extremely narrow hinge, and the elongated beak. Early members of the genus suggest juveniles of *Triplesia*.

Onychoplecia is first seen in the Table Head series of Newfoundland in a small, strongly folded species. It is fairly common in Chazy rocks (Crown Point) of New York. It is less common in Marmor rocks of Pennsylvania and Tennessee. The youngest specimens known are from the Lower Bromide of Oklahoma and the Sevier of East Tennessee, the latter from about the Benbolt level probably being the younger.

ONYCHOPLECIA BREVIROSTRIS Cooper, new species

Plate 99, K, figures 65-70; plate 100, D, figures 15-22; plate 100, F, figures 28, 29

Shell small, but of fairly large size for the genus, tear-shaped in outline, compressed lenticular in profile; sides rounded and with greatest shell-width located anterior to the middle; front margin somewhat truncated. Anterior commissure more or less broadly uniplicate. Surface marked by fine concentric lines of growth.

Pedicle valve subtriangular in outline with the anterolateral margins strongly rounded but the posterolateral margins nearly straight and making an angle of 85°. Lateral profile gently convex in the posterior two-thirds, moderately convex in the anterior third. Anterior profile broadly and moderately convex. Sulcus broad and shallow, confined to the anterior third; tongue short, broadly rounded. Median region and flanks swollen, interarea moderately long, pseudodeltidium with prominent and fairly wide elevated ridge.

Brachial valve nearly circular in outline; lateral profile strongly convex and with the greatest convexity at about the middle; anterior profile strongly convex; fold formed by a broad wave of the anterior commissure toward the brachial valve; fold only slightly visible at the anterior third as a narrow, short subcarinate elevation. Brachial interior with forked cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 6.6 | 5.5 | 6.1 | 2.6 | 3.3 |
| Paratype (117089e) | 5.4 | 4.7 | 4.8 | 1.9 | 1.8 |

Types.—Holotype: 117089a; figured paratypes: 117089b-e; figured specimens: 118009a,b.

Horizon and locality.—Lenoir formation in Tennessee: From the calcarenites under the Mosheim calcilutite of the southwest side of the cemetery at Friends Church, north corner of Friendsville, Concord (T.V.A. 138-SW) Quadrangle. Also, 3 feet above the Mosheim limestone south of the Friends Church, same locality.

Discussion.—This species is characterized by its fairly short beak, the wide apical angle, which is almost a right angle, the modest convexity of the valves, and the moderate folding of the anterior commissure. It thus differs from *O. longirostris* and *O. gracilis* which have more attenuate pedicle valves. *Onychoplectia obesa* attains a much greater swelling of the brachial valve, and its pedicle beak is more slender than that of the Friendsville species.

This little species is uncommon and hard to find. It occurs above and below the "Mosheim" calcilutite. In the higher occurrences it appears in a coarse calcarenite and the valves are generally separated. The specimens from below the "Mosheim" band were taken from a shale patch in the calcarenites.

ONYCHOPLECTIA GRACILIS (Raymond)

Plate 100, C, figures 11-14

Triplecia gracilis RAYMOND, Bull. Amer. Paleont., vol. 3, p. 303, pl. 18, fig. 1, 1902.

Camerella longirostra RAYMOND (not Billings), Ann. Carnegie Mus., vol. 7, No. 2, p. 249, pl. 36, figs. 29, 30, 1911.

Fairly large for the genus, elongate tear-shaped in outline; sides rounded; pedicle beak elongate with concave lateral margins; anterior commissure strongly uniplicate. Surface marked by strong, regular concentric lines.

Pedicle valve with elongated beak forming an apical angle of about 50°. Lateral profile gently concave to flat in posterior part, moderately convex on body of shell; anterior profile broadly and moderately convex. Median region swollen. Sulcus short, narrow, deep, originating slightly anterior to the middle and occupying slightly less than half the width at the front margin. Posterolateral slopes moderately steep; anterolateral slopes gentle. Interior with divergent dental lamellae.

Brachial valve broadly oval in outline with the maximum width anterior to

the middle; strongly convex in lateral profile with the maximum convexity at about the middle; anterior profile strongly and broadly convex; umbonal and median regions swollen; lateral slopes short and steep; fold short, narrowly rounded, originating about 3 mm. anterior to the beak; anterolateral extremities separated from anterior end of fold by oblique grooves, swollen and rounded.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (Carnegie Mus. 5457)..... | 6.3 | 5.5 | 5.3 | 2.3 | 2.7 |
| " (123293a) | 4.7 | 4.0 | 4.0 | 1.4 | 2.2 |

Types.—Figured hypotype: Carnegie Mus. 5457; measured hypotype: 123293a.

Horizon and locality.—Crown Point formation in New York: On Valcour Island; quarry $\frac{1}{4}$ mile northeast of the Normal School, Plattsburg, Plattsburg (15') Quadrangle.

Same formation in Vermont: On Isle LaMotte, Rouses Point (15') Quadrangle.

Discussion.—This species was assigned by Raymond in his 1911 revision of the Chazyan brachiopods to *O. longirostris* Billings. The two species, however, do not seem to be the same. The apical angle of *O. gracilis* indicates a species with more attenuate beak than that of Billings' species. Billings' figures, however, indicate a specimen with exceedingly acuminate beak. Examination of the type specimen, however, did not confirm this view. The pedicle sulcus of *O. gracilis* is longer, narrower, and deeper than that of *O. longirostris*. Consequently, the folds of the two species are different; that of Raymond's species is usually longer, narrower, and more prominent.

The New York and Vermont species is unlike *O. obesa* because of its less convex brachial valve, wider and shallower sulcus, and the greater length and narrowness of the fold. Raymond's species is abundant in places in the Crown Point formation of the Chazy group.

ONYCHOPLECIA KINDLEI Cooper, new species

Plate 100, B, figures 4-10

Shell small for the genus, subtriangular in outline; sides gently rounded; anterolateral extremities narrowly rounded; anterior margin straight to medially indented; apical angle about 70° . Anterior commissure narrowly uniplicate. Surface smooth, but exfoliated specimens are marked by fine, distant radial costellae.

Pedicle valve subtriangular in outline, lateral profile gently to strongly convex with the maximum depth at about the middle; anterior profile moderately to strongly and broadly convex with a median depression formed by the sulcus. Umbo smooth and flat; sulcus originating on the umbo $\frac{1}{2}$ to 1 mm. anterior to the beak, shallow and narrow at the posterior of the shell but deepening and widening anteriorly where it occupies about half the width; flanks bounding sul-

cus swollen and with steep lateral slopes. Beak elongated, hinge narrow, pseudo-deltidium marked by characteristic median ridge.

Brachial valve oval in outline with a moderately to strongly convex lateral profile; anterior profile broadly and moderately convex and marked medially by a narrow fold; umbo swollen; median region inflated; fold narrowly rounded, low, barely perceptible at the umbo but becoming prominent at about the middle; fold subcarinate in profile, separated from the swollen flanks by shallow, oblique grooves.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 3.7 | 3.3 | 3.4 | 1.5 | 2.0 |
| Paratype (pedicle valve 117092c)..... | 5.4 | ? | 5.3 | ? | 2.6 |
| “ (brachial valve 117092b).... | ? | 3.5 | 3.9 | ? | 2.0 |

Types.—Holotype: 117092a; figured paratypes: 117092b,d; unfigured paratype: 117092c.

Horizon and locality.—Table Head series in Newfoundland: At Table Point Cove.

Discussion.—This species is characterized by its small size, its long, deep, and angular sulcus, and the prominent, long, narrowly rounded fold. This folding distinguishes the species from all others now described.

ONYCHOPLECIA LONGIROSTRIS (Billings)

Plate 100, A, figures 1-3

Camarella longirostra BILLINGS, Canadian Nat. Geol., vol. 4, p. 302, 1859; Geol. Canada, p. 127, fig. 53, 1863.

Camarella ? longirostris Billings, TWENHOFEL and WHITING in Twenhofel, Geol. Soc. Amer. Special Pap. 11, pp. 30, 53, pl. 7, figs. 25-27, 1938.

Shell of about usual size for the genus, tear-shaped in outline with an attenuate beak; lateral margins rounded; apical angle about 70° ? Anterior commissure broadly uniplicate. Surface smooth.

Pedicle valve moderately convex in lateral profile and with the maximum convexity located just posterior to the sulcus; anterior profile broadly, moderately, and evenly convex; umbonal region flattened; median region moderately swollen; sulcus confined to the anterior quarter, wide, shallow, and defined by a narrow, oblique fold on each side; sulcus in width equal to about half the shell width. Lateral regions somewhat swollen and with moderately steep slopes to the margins. Divergent dental plates visible at beak.

Brachial valve subcircular in outline; lateral profile strongly convex; anterior profile strongly convex; maximum convexity at the middle where the valve is strongly swollen; fold defined in the anterior quarter only, demarcated by shallow oblique grooves; fold rounded. Lateral slopes steep.

Measurements in mm.—Holotype, length 7.0?, brachial length 6.1, width 6.2, hinge width 2.8, thickness 3.5.

Type.—Holotype: G.S.C. 1039.

Horizon and locality.—Mingan formation (about 25 feet above the base according to Twenhofel and Whiting) on Quarry and Quin Islands, Mingan group, St. Lawrence River, Quebec, Canada.

Discussion.—This species is characterized by its short fold, rotund and tumid brachial valve, and moderately acute pedicle beak. It is not a common species, according to reports, and is confined to the lower part of the Mingan formation on two islands of the Mingan group. The distinctions between this species and *O. gracilis* Raymond are stated under that species. This is the only described species with which the Mingan form might be confused.

ONYCHOPLECIA MATUTINA Cooper, new species

Plate 121, F, figures 15-17

Shell small, suboval in outline, apical angle about 100° ; sides rounded; anterior commissure uniplicate; surface smooth but where exfoliated, shell is marked by radial lines as usual in the Triplesiidae.

Pedicle valve moderately convex in lateral profile; somewhat narrowly convex in anterior profile; umbo somewhat narrowly swollen; median region inflated; sulcus originating at about the middle, short and deep and occupying about half the width. Flanks bounding sulcus narrowly swollen and with steep slopes.

Brachial valve moderately convex in anterior and lateral profile; umbonal region swollen; fold originating just posterior to the middle, narrowly convex in the middle and with moderately sloping sides. Flanks moderately inflated.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 5.7 | ? | 6.8 | ? | 1.2 ? |
| Paratype (117941b) | ? | 5.0 | 6.3 | ? | 0.8 ? |

Types.—Holotype: 117940a; figured paratypes: 117941a,b.

Horizon and locality.—Basal Everton formation in Arkansas: At the northwest edge of Pindall, near the school, Yellville (30') Quadrangle.

Jasper formation in Arkansas: Just northwest of Pindall, Yellville (30') Quadrangle.

Discussion.—This species is unlike any others of this genus described in its transversely elliptical form, short, wide-angled beak, short deep sulcus and moderately convex brachial valve. The species is of note because it is one of the few fossils found in the Everton and Jasper formations.

ONYCHOPLECIA OBESA Cooper, new species

Plate 100, E, figures 23-27

Large for the genus, broadly oval in outline; sides rounded and anterior margin straight. Apical angle about 75° . Anterior commissure broadly and deeply uniplicate in adults. Surface marked by concentric lines of growth and obscure radial lines.

Pedicle valve oval in outline with uneven lateral profile, the greatest depth in the median region; anterior profile moderately convex; median region inflated; sulcus broad and shallow; tongue short and rounded.

Brachial valve broadly elliptical, width slightly greater than length; lateral and anterior profile strongly convex; valve deep and tumid; umbonal and median regions inflated and with precipitous slopes to the margins. Fold inconspicuous and short, defined at the anterior quarter only; plication of anterior commissure deep.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|---------------------------------|--------|-----------------|-------|-----------|
| Holotype (brachial valve) | ? | 7.2 | 8.4 | 4.4 |
| Paratype (pedicle valve) | 5.6 | ? | 5.3 | 1.7 |

Types.—Holotype: 117090b; figured paratype: 117090a.

Horizon and locality.—Row Park formation (*Maclurites* bed) in Pennsylvania: About 175 feet above the "Mosheim" limestone at the base of the Row Park formation, $\frac{1}{8}$ to $\frac{1}{4}$ mile east-northeast of the railroad cut, $2\frac{1}{2}$ miles southwest of Marion, Chambersburg (15') Quadrangle.

Same formation in Maryland: From the *Maclurites* bed in the ledge overlooking the Potomac River in quarry at Pinesburg Station, Williamsport (15') Quadrangle.

Discussion.—This species is larger and unlike other described species of *Onychoplecia*. It is characterized by its fairly flattish pedicle valve, and extremely swollen but well-rounded brachial valve. In the latter respect it differs from *Triplesia carinata* from Pratt Ferry, Ala., which it resembles. The southern species is characterized by its extreme depth, but it has a strong subcarinate fold. The Pennsylvania species, on the other hand, has a tumid brachial valve but the fold is inconspicuous on the body of the shell and may be seen only at the front margin where it shows as a wave of the commissure. Differences of these sorts in the brachial valves indicate that the pedicle valves, too, will be quite unlike. The sulcus of *O. obesa* is short, wide, and shallow; that of *Triplesia carinata*, on the other hand, is deep, wide, and has a strong median groove within the sulcus.

ONYCHOPLECIA TENUIS Cooper, new species

Plate 100, K, figure 50

About medium size for the genus, tear-shaped in outline with rounded sides and attenuate beak forming an angle of slightly more than 70° . Anterior commissure perceptibly uniplicate with a suggestion of costation along the margin. Surface smooth.

Pedicle valve gently convex in lateral profile with the maximum convexity in the median region; anterior profile more convex than that of the lateral view, broad and moderate. Umbonal region somewhat flattened; median region somewhat swollen; lateral slopes gentle. Sulcus in an incipient stage. Beak long; pseudodeltidium with narrow longitudinal elevation.

Brachial valve oval in outline, gently convex in lateral and anterior profiles but both profiles with a greater convexity than those of the pedicle valve. Umbonal and median regions gently inflated; lateral slopes short, moderately steep. Fold not defined.

Measurements in mm.—Holotype, length 5.1, brachial length 4.2, width 4.4, hinge width 1.6, thickness 1.6.

Type.—Holotype: 117091.

Horizon and locality.—Lower Bromide formation (Mountain Lake member) in Oklahoma: On the McLish Ranch, sec. 24, T. 1 S., R. 7 E., Johnston County.

Discussion.—This species is characterized by the modest convexity of its valves. In this respect it is unlike any other described form. It is closest to *O. brevirostris* but is flatter and has a more attenuated beak.

When the fold and sulcus of this species are studied with care, a suggestion of anterior folding or costation can be seen. The costae are very indistinct and can only be detected by examination of the commissure. Inasmuch as this is the youngest species of this primitive genus yet seen, this anterior costation might indicate a trend in its folding not seen in older forms. It might also indicate that the specimen is actually a young form of a costellate triplesid such as *Oxoplecia*. Members of that genus are abundant in parts of the Bromide formation of Oklahoma, but all the many specimens examined by the writer show the costation originating on the beak. The specimen assigned to *Onychoplecia* is quite smooth over the entire surface except at the commissure.

ONYCHOPLECIA sp. 1

Plate 121, C, figures 9-12

Four specimens of *Onychoplecia* taken from high in the Sevier formation are interesting because they represent the youngest specimens of this genus yet found and because they indicate another undescribed species. Unfortunately, the specimens are not adequate on which to base a species. The material consists of one immature pedicle valve and two brachial valves which are probably mature.

The pedicle valve is 5.8 mm. long and 5.1 mm. wide at the widest part which is anterior to the middle. The beak angle is about 70°, and the anterior is narrowly rounded. In profile the maximum convexity is anterior to the middle. A trace of a sulcus is to be seen at the anterior, but the shell is so young that this adult character had not yet developed. A second pedicle valve is represented by an imperfect impression which is clearly adult but has a long and deep sulcus. The specimen has some camerellid features, but there is no way to prove the true generic affinities. Although one of the brachial valves mentioned below also has camerellid features, its interior details indicate that it is a triplesid.

Two brachial valves are present in the collection. One of these (117096b) has a moderately prominent fold which is wrinkled by 3 costae. This is an unusual feature for these triplesids, but the interior shows no median septum or other camerellid features. The second brachial valve (117096d) is clearly a triplesid. The shell is nearly smooth and has a subcarinate fold originating near the middle.

The shell is swollen on the flanks and in the median region just posterior to the point where the fold originates. The specimen is unfortunately incomplete. Possibly two distinct species are represented by the material.

Figured specimens.—117096a-c; unfigured specimen: 117096d.

Horizon and locality.—Sevier formation (at the top of sandstone number 5) in Tennessee: 0.28 mile northwest of Fourmile Church, Tallassee (T.V.A. 139-SE) Quadrangle.

Genus **TRIPLESIA** Hall, 1859

Triplesia HALL, Pal. New York, vol. 3, p. 522, 1859.—ULRICH and COOPER, Journ. Paleont., vol. 10, No. 5, p. 345, 1936.

This genus is rare in most of the strata embraced by this book and from most of the geographic areas. It is commonest in the Rockland (Napanee member) of the Trenton group of New York where it has long been known. No authentic specimens of the genus have to date been taken from the Appalachians north of Tennessee, although it has been reported at a number of places. A well-marked species, however, appears in the Lebanon limestone of the Central Basin of Tennessee that had not hitherto been reported. This occurrence helps to emphasize the post-Black River position of this formation. A triplesid of uncertain generic affinities is known from the Little Oak limestone of Alabama.

Triplesia and *Onychoplecia* are closely related genera, and the former probably descended from the latter. Widening of the hinge and consequent shortening of the pedicle beak is about all that is necessary to produce *Triplesia* from *Onychoplecia*.

TRIPLESIA CARINATA Cooper, new species

Plate 100, I, figures 41-43

Known chiefly from the brachial valve, but a probable immature pedicle valve gives a clue to the generic character of the species. Large for the genus, wider than long; oval in outline; sides narrowly rounded; hinge narrow; anterior somewhat trilobate. Anterior commissure deeply uniplicate with prominent brachial fold and deep pedicle sulcus. Surface smooth, exfoliated areas marked by distant costellae.

Pedicle valve tentatively defined as having gentle lateral profile, and broad, gently convex anterior profile; beak somewhat elongated; sulcus originating near the middle, deep and angular in section with a deep central groove; tongue extremely long and angular. Median region gently swollen. Sulcus bounded by oblique, angular plicae. Foramen small, elongate; dental plates elongate and narrowly divergent.

Brachial valve forming a rounded ellipse in outline, widest at about the middle; lateral profile strongly convex and with greatest depth in the midregion; anterior profile strongly domed and with a narrow median elevation. Umbonal region narrow, swollen; median area inflated; fold originating on the umbo, strongly elevated, subcarinate in section, demarcated by an oblique groove which divides the narrowly swollen flanks from the steep sides of the fold. All slopes steep.

Brachial interior with short and narrowly triangular chilidium; cardinal process moderately long, slender, myophore forked, prongs moderately divergent.

Measurements in mm.—Holotype (brachial valve), brachial length 8.3, width 10.2, hinge width 4.6, thickness 7.1.

Types.—Holotype: 117095a; unfigured paratype: 117095b.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—Inasmuch as the true nature of the pedicle valve of this species is somewhat uncertain, the species is based on the brachial valve as holotype. This valve is distinctive and differs from all others known by its great depth, inflated flanks and fold, and subcarinate and strongly elevated fold.

The species most suggestive of the Pratt Ferry one is *Cliftonia grayae* (Davidson) from the Stinchar limestone group, Craighead, Girvan District, Scotland.

TRIPLESIA SUBCARINATA Cooper, new species

Plate 100, H, figures 35-40

Shell small for the genus, syntrophoid in outline and profile. Valves unequally convex, sides narrowly rounded and hinge narrower than the shell width. Smooth exterior but exfoliated specimens with fine distant costellae.

Pedicle valve slightly convex in lateral profile with a central tongue bent almost at right angles to the length. Sulcus originating at about the middle widening rapidly to occupy about three-fourths the width at the place of geniculation of the tongue. Flanks gently convex; slopes to margins moderately steep. Sulcus and tongue marked by a narrow, shallow median groove.

Brachial valve moderately convex in lateral profile with the greatest convexity at about the middle; steeply subcarinate in anterior profile. Beak small, umbo narrowly rounded with a slight elevation continued anteriorly to join the fold which originates at about the middle. Fold narrowly rounded with somewhat swollen sides, separated from body of shell by narrow grooves. Flanks slightly inflated, with steep lateral slopes. Cardinal process a long slender fork.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 9.4 | ? | 11.0 | 8.0 ? | 2.0 ? |
| Paratype (brachial valve 117094b)... | ? | 9.2 | 11.0 | 8.0 ? | 5.9 |

Types.—Holotype: 117094a; figured paratype: 117094b; unfigured paratypes: 117094c-e.

Horizon and locality.—Lebanon formation in Tennessee: At Columbia, Maury County.

Discussion.—*Triplesia subcarinata* is suggestive of *T. extans* of the New York Trenton but differs in having the fold and sulcus originating near the middle of the valve instead of on the umbo as in the latter species. Besides this important feature the Tennessee species is smaller in size and has a sharper fold. Furthermore, the young of *T. extans* that correspond in size to *T. subcarinata* are not nearly so deep nor so rotund as the New York species.

TRIPLESIA sp. 1

Plate 121, D, figure 13

A single imperfect pedicle valve of this unusual genus was taken in the black limestones of the Whitesburg formation at Bulls Gap. The specimen is 6.7 mm. long and has the same distance as its maximum width. The sulcus originates at about the valve middle and widens and deepens rapidly. The sulcus is bounded by short, somewhat obliquely curved folds. The beak is moderately long and shows two short divergent dental plates through the translucent shell. The median region is moderately swollen.

Figured specimen.—117097.

Horizon and locality.—Whitesburg formation in Tennessee: $1\frac{1}{2}$ miles west of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Genus OXOPLECIA Wilson, 1913

Oxoplectia WILSON, Victoria Mem. Mus. Bull., vol. 1, pp. 81-86, 1913.—ULRICH and COOPER, Journ. Paleont., vol. 10, No. 5, p. 337, 1936.

OXOPLECIA ABNORMIS Cooper, new species

Plate 104, G, figures 39-44

Shell small, transversely elliptical in outline with narrowly rounded lateral margins and truncated front margin. Greatest width at about the middle; unipli-cate. Surface costellate, with 2 costellae occupying the sulcus and 3 on the fold. Flanks marked by 8 costellae produced by the bifurcation and implantation of 2 or 3 primary costellae on each side of the fold and sulcus.

Pedicle valve gently convex in lateral profile with the greatest curvature in the umbonal region. Sulcus originating just anterior to the umbo and widening anteriorly to occupy about one-third the valve width at the front margin. Flanks bounding sulcus gently convex; posterolateral slopes to cardinal extremities steep. Interarea apsacline, moderately long and narrow.

Brachial valve strongly convex in lateral profile and with the greatest convexity in the posterior half. Umbonal region full but not conspicuous. Fold originating just anterior to the umbo, low throughout its length. Flanks bounding fold gently convex in profile, with moderate slopes to the margins.

Measurements in mm.—Holotype, length 8.8, brachial length 7.8, width 13.4, hinge width 7.0?, thickness 5.8.

Type.—Holotype: 110842.

Horizon and locality.—Effna formation in Virginia: 1 mile east of Tilson Mill, 16 miles northeast of Marion, Nebo (T.V.A. 223-NW) Quadrangle.

Discussion.—This species is best distinguished by its narrowly and transversely elliptical outline which sets it off from any other species described herein. The species occurs with *Oxoplectia holstonensis* but differs from that species in ornamentation, development of fold and sulcus, and convexity of valves as well as outline.

OXOPLECIA COSTELLATA Cooper, new species

Plate 138, B, figures 8, 9

Shell of about medium size for the genus, wider than long and with sides rounded. Surface marked by closely crowded rounded costellae, 8 on the fold, 7 in the sulcus, and 18 on the flanks.

Pedicle valve gently convex in anterior and lateral profiles; sulcus broad and shallow; tongue moderately long and broadly rounded; flanks flattened and with gentle slopes to the sides. Brachial valve moderately convex in lateral profile and fairly strongly arched in anterior profile. Fold originating just posterior to the middle, moderately elevated and with costellae of the flanks crowded to its sides.

Measurements in mm.—Holotype, length 10.1+, brachial length 9.1, midwidth 12.3, hinge width 9.0, thickness 6.0.

Type.—Holotype: 117126.

Horizon and locality.—Whistle Creek formation in Virginia: From a cut on U. S. Highway 60, 100 yards southeast of Whistle Creek, 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species is characterized by its flattish pedicle valve and closely crowded costellae. In these respects it suggests *O. planiventra* and *O. recta*. It differs from the former in having only 6 costellae on the fold and a much less convex brachial valve. It differs from the latter in having finer costellae.

OXOPLECIA DEPRESSA Cooper, new species

Plate 100, J, figures 44-49

Shell small, transversely elliptical in outline and with rounded sides and gently rounded anterior margin. Anterior commissure moderately uniplicate. Surface marked by 9 costellae on the fold, 7 or 8 in the sulcus, and 16 costellae on the flanks; costellae rounded and crowded, often bifurcated or intercalated at the margin.

Pedicle valve gently convex, most convex just anterior to the umbo; anterior profile broadly and faintly convex; umbonal region swollen; sulcus originating just posterior to the middle, shallow throughout and forming a short, broadly rounded tongue. Flanks bounding sulcus gently concave and with moderately sloping surface. Interarea short, apsacline.

Brachial valve strongly convex in lateral profile and strongly domed in anterior profile; umbonal and median regions strongly swollen; flanks moderately swollen and with steep sides. Fold inconspicuous, discernible only at the anterior and merged with the flanks and swollen median region.

Measurements in mm.—Holotype, length 8.3, brachial length 7.7, midwidth 10.5?, hinge width 6.8, thickness 5.3.

Types.—Holotype: 117100b; unfigured paratype: 117100a.

Horizon and locality.—Effna formation in Virginia: 4 miles southwest of Bland, Bland County.

Discussion.—This species is unlike any other described herein in the modest

development of the fold and sulcus. Its closely crowded ornamentation is suggestive of *O. costellata*, but that species is more strongly ornamented and has a strong fold and sulcus.

OXOPLECIA EIDSONENSIS Cooper, new species

Plate 104, B, figures 7-11; plate 104, F, figures 32-38

Shell of about medium size for the genus, transversely elliptical in outline, with narrowly rounded lateral margins and broadly rounded anterior margin. Pedicle valve fairly deep. Surface multicostellate with the fold occupied by 4 to 8 costellae and the sulcus by 3 to 7 costellae. Flanks marked by 12 costellae. Intercalation of costellae occurring just anterior to the umbo. Surface covered by concentric fila, about 4 to the millimeter on the flanks.

Pedicle valve evenly and gently convex in lateral profile; anterior profile broadly convex but depressed medially by the sulcus. Beak slightly incurved. Sulcus originating just anterior to the umbo, about $2\frac{1}{2}$ mm. anterior to the end of the beak; sulcus moderately deep and widening rapidly to the front margin where it occupies about half the shell width. Costellae bounding sulcus stronger than others on flanks; flanks gently convex but with steep slopes to the margins. Interarea apsacline; hinge equal to about half the valve width; deltidial ridge strongly elevated. Dental plates widely divergent.

Brachial valve strongly convex in lateral profile with the maximum convexity in the umbonal region; anterior profile strongly convex and with a median elevation formed by the fold. Umbo swollen; fold originating about 2 mm. anterior to the beak, low, rising slightly anteriorly and never strongly elevated; flanks inflated and with steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.0 | 11.9 | 15.9 | 10.1 | 10.6 |
| Paratype | 11.7 | 10.6 | 13.7 | 7.9 | 8.2 |

Types.—Holotype: 110847b; figured paratype: 110847a.

Horizon and locality.—Lincolnshire formation in Tennessee: On old pasture road $\frac{1}{2}$ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Same formation in Virginia: 1 mile northeast of Jeff Gillespie's house, 14.4 miles southwest of Tazewell, Tazewell County.

Discussion.—This species is characterized by a fairly strongly convex brachial valve and a moderately convex pedicle valve, a fairly deep pedicle sulcus but only a moderately elevated brachial fold. The species most closely resembles *Oxoplectra planiventra* but has a more convex pedicle valve and more robust form. *Oxoplectra recta* from the closely related Hogskin member of the Lincolnshire formation resembles *O. eidsonensis* more remotely than *O. planiventra*. *Oxoplectra eidsonensis* is larger and more robust than the Hogskin species but it is also proportionately wider and more strongly elliptical in outline.

OXOPLECIA FILOSA Cooper, new species

Plate 103, A, figures 1-12

Shell large, slightly wider than long, subcircular in outline; sides broadly rounded; hinge narrow; anterior margin broadly rounded; uniplicate; valves unequal in depth, the brachial valve usually considerably deeper; surface costellate, costellae low and rounded, separated by spaces about equal in width to the width of the costellae; costellae becoming broad and subdued on the anterior margin; 12 costellae on the flanks; fold and sulcus with variable number from 5 to 8.

Pedicle valve unequally convex in lateral profile the greatest convexity located in the posterior third; anterior profile broadly and gently convex; sulcus originating 4 to 5 mm. anterior to the beak, shallow in the median region, only moderately deep at the margin where it occupies less than half the width. Sulcus bounded on each side by a narrow plica consisting of 2 costellae somewhat more elevated than those on the outside; flanks gently convex; slopes moderate. Interarea long, curved, moderately apsacline; beak moderately protruding. Tongue long and narrow.

Brachial valve gently convex in lateral profile except for the umbo which is inflated; anterior profile strongly and broadly convex; fold originating about 5 to 6 mm. anterior to the beak, very low on the middle of the valve and not becoming more than moderately elevated at the front margin; flanks bounding fold swollen and convex and with steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 20.5 | 17.7 | 21.6 | 13.1 | 11.3 |
| Paratype | 14.0 | 12.8 | 17.9 | 12.6 | 8.9 |

Types.—Holotype: 117099a; figured paratype: 117099b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: Road cut on Oklahoma Highway 18, center NW $\frac{1}{4}$ sec. 11, T. 1 S., R. 3 E., 1.8 miles south of Sulphur, Murray County.

Discussion.—This is one of the larger species of *Oxoplecia* which is ornamented by slender costellae. It thus resembles *O. gouldi*, *O. nevadensis*, and *O. multicostellata*. *Oxoplecia filosa* differs from *O. gouldi* in its much rounder outline, the length and width being nearly equal; the interarea is longer, so that the beak is more elevated above the brachial umbo; the pedicle valve is less deep than that valve in *O. gouldi*; the fold originates nearer the center of the brachial valve than in *O. gouldi*, and the sulcus of the latter is deeper than that of *O. filosa*.

Oxoplecia nevadensis has a stronger fold and sulcus than *O. filosa* and its valves are deeper, the outline is more transverse, and the pedicle beak is less erect.

Oxoplecia filosa differs from *O. multicostella* in its less prominent fold and sulcus, the sulcus of the latter species originating far up on the umbo; it differs in its more compressed form, less exposed pedicle interarea and more inflated umbonal region.

Oxoplectia planulata also has a compressed outline and thus suggests *O. filosa*, but the compression is more exaggerated and it has a wider and more elevated fold than the Oklahoma species.

OXOPLECTIA GIBBOSA Cooper, new species

Plate 102, A, figures 1-17

Shell a little below medium size for the genus, roundly elliptical in outline, unequally biconvex in lateral profile. Lateral margins narrowly rounded; anterior margin truncated. Sulcus occupied by 2 to 3 costellae and the fold by 3 or 4. Flanks marked by about 6 costellae. Fila numbering 3 to 4 in a millimeter near the middle of the valve.

Pedicle valve moderately convex in lateral profile and with prominent and erect beak; anterior profile broadly and gently convex; umbonal region convex; sulcus originating slightly posterior to the middle, widening and deepening rapidly to occupy about half the valve width at the front margin. Tongue long and rounded. Flanks slightly convex to slightly concave in profile; lateral slopes moderate. Hinge width equal to about half the valve width. Interarea short; deltidial ridge low; interarea gently to strongly apsacline.

Brachial valve half again as deep as the pedicle valve, strongly convex in lateral profile with greatest convexity posterior to the middle. Beak prominent, overhanging hinge margin. Umbo swollen. Fold originating at place of maximum curvature, low throughout its extent. Flanks gently convex with very steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.5 | 11.4 | 14.9 | 6.5 | 9.6 |
| Paratype (110855a) | 10.0 | 9.5 | 13.2 | 5.8 | 8.0 |
| " (110855c) | 9.3 | 8.6 | 11.1 | 5.1 | 7.0 |

Types.—Holotype: 110860; figured paratypes: 110855a,c; unfigured paratype: 110855b.

Horizon and locality.—Ward Cove formation in Tennessee: At Inskip, E 2, 604, 600-700/N-596, 350 (military coordinates), Fountain City (T.V.A. 146-SW) Quadrangle; Hickey place, 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; Evans Ferry, Howard Quarter (T.V.A. 162-NW) Quadrangle; $\frac{3}{4}$ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; $\frac{1}{2}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Red Knobs formation in Tennessee: 1 mile north and $\frac{3}{4}$ mile northwest of Meadow Station, Meadow (T.V.A. 139-NW) Quadrangle, $1\frac{1}{2}$ miles east of Friendsville, and 1 mile south of Louisville, Louisville (T.V.A. 138-SE) Quadrangle.

Base of "Ottosee" = Ward Cove horizon in Tennessee: At 1 mile southeast of Whitehorn, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Little Oak formation in Alabama: At Hebron Church, 6 miles southwest of

Leeds, Leeds (15') Quadrangle; Ragland Cement Company Quarry, 3 miles southeast of Ragland, St. Clair County.

Ward Cove formation in Virginia: At Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Effna formation in Virginia: At McNutt Quarry 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Discussion.—*Oxoplectia gibbosa* as described herein is a variable species. The variation may be due in part to preservation because some of the specimens are loose silicified shells while others are enclosed in a limestone matrix. The costae on the flanks vary from strong to almost obsolete; consequently, some specimens have a quite different appearance from others and the species is difficult to identify and distinguish from nearly related forms. Generally *O. gibbosa* is fairly round in outline but has deep valves. It resembles *O. holstonensis* in outline but is more strongly and less numerously costellated than that species. It is also a more robust species than *O. parva*, a rare shell from the Benbolt formation.

Oxoplectia gibbosa differs from *O. eidsonensis* in having less numerous and strong costellae and a rounder form. It differs from *O. planiventre* in its much more robust and deep pedicle valve.

OXOPLECTIA GLOBULARIS Cooper, new species

Plate 106, B, figures 6-11

Shell of about medium size for the genus, subcircular in outline with sides broadly rounded and anterior margin nearly straight. Strongly inequivalve, the brachial valve having the greater depth. Strongly uniplicate. Sulcus with 3 to 5 costellae; fold with 4 to 6 costellae. Flanks with about 9 costellae. Costellae broad, separated by interspaces about equal to the costellae in width. Fila closely crowded, 7 or 8 to the millimeter.

Pedicle valve moderately convex in lateral profile and broadly but gently convex in anterior profile. Sulcus originating about 3 mm. anterior to the beak, widening to the front margin where it occupies about two-thirds the width; pedicle tongue long and subtruncate anteriorly; flanks bounding sulcus narrow, convex, and with steep slopes. Beak and interarea short, strongly curved.

Brachial valve strongly convex in lateral profile with the most convex part in the umbonal region; anterior profile strongly arched and with precipitous sides. Umbonal region smooth; fold moderately elevated above the flanks; flanks somewhat inflated.

Measurements in mm.—Holotype, length 13.9, brachial length 13.4, width 15.7, hinge width 6.8, thickness 12.2.

Types.—Holotype: 117098b; figured paratype: 117098c; unfigured paratype: 117098a.

Horizon and locality.—Base of Martinsburg formation (part with *Brogniatella*=*Salona*) in Virginia: On Virginia County Highway 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is characterized by its round outline and the great

depth of its valves, particularly the brachial valve. It is also strongly costellate and has a deep sulcus and strong fold. It strongly simulates a robust form of *Parastrophina* with which it occurs. These features distinguish the species from any of the forms described herein, even *O. gibbosa* which is generally somewhat smaller, more sparsely costellate, and with both valves less deep.

OXOPLECIA GOULDI Ulrich and Cooper

Plate 103, C, figures 17-29

Cliftonia gouldi DECKER, Oklahoma Geol. Surv. Bull. 55, p. 42, pl. 13, fig. H (nomen nudum), 1931.

Cliftonia (Oxoplectia) gouldi ULRICH and COOPER, Journ. Paleont., vol. 10, No. 5, p. 338, pl. 50, figs. 8, 15, 18, 19, 23, 28, 32, 36, 1936.

Types.—Holotype: 91897; paratypes: 91898a,b; 91899; figured hypotypes: 110876, 118010.

Horizon and locality.—Bromide formation (Pooleville member—*Oxoplectia gouldi* zone) in Carter County, Okla.: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills; NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E.; NE $\frac{1}{4}$ sec. 1, T. 2 S., R. 2 W, 3 miles east of Pooleville, Carter County. Same formation and member in Murray County, Okla.: 20 feet above the green shale on Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County.

OXOPLECIA HOLSTONENSIS Willard

Plate 99, J, figures 62-64; plate 100, G, figures 30-34; plate 101, D, figures 23-43

Oxoplectia holstonensis WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 287, pl. 3, fig. 17, 1928.

Shell of about medium size for the genus, nearly circular or slightly elliptical in outline, with well-rounded lateral extremities and truncated anterior margin. Surface costellate with 2 to 5 costellae occupying the sulcus and 3 to 6 on the fold. Costellae on flanks variable in number, generally about 10.

Pedicle valve most convex in the posterior half, flattened or gently convex in the anterior half. Sulcus originating slightly posterior to the middle, moderately deep, and occupying about half the width at the front of the valve. Tongue moderately long. Flanks bounding sulcus gently convex; lateral slopes moderately steep. Hinge width equal to or slightly less than half the shell width. Interarea short.

Brachial valve very strongly convex in lateral and anterior profiles. Umbonal region not prominently swollen; beak not extending beyond posterior margin. Fold originating about one-third the length from the beak, only slightly elevated above the flanks throughout its length. Flanks most convex near the fold and with steep slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve)..... | 10.5 | ? | 12.4 | ? | ? |
| Hypotype (123296a) | 9.0 | 8.1 | 10.3 | 6.8 | 6.5 |
| “ (117105b) | 10.0 | 9.8 | 12.8 | 6.7 | 6.3 |

Types.—Holotype: M.C.Z. 8632; figured hypotypes: 117102a,b, 117105b, 117106b-f, 117107, 117108; measured hypotype: 123296a.

Horizon and locality.—Effna formation in Virginia: At the McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; 1 mile east of Tilson Mill, 16 miles northeast of Marion, Nebo (T.V.A. 223-NW) Quadrangle.

Botetourt formation in Virginia: 1 to 2 miles northwest of Lexington, Lexington (15') Quadrangle; Cedar Grove Church, 1½ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle; 4 miles east of Catawba, Salem (15') Quadrangle; junction Virginia Highways 721 and 724, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle; 3 miles northeast of Blacksburg, Blacksburg (15') Quadrangle.

Basal Edinburg formation (Liberty Hall facies) in Virginia: On the boundary of George Washington Forest, 1.8 miles S. 4° W. of Bethel Church, 5.9 miles due east of Harrisonburg, Harrisonburg (15') Quadrangle; 1 mile northwest of Lexington, Lexington (15') Quadrangle.

Whitesburg formation in Tennessee: Under the railroad bridge east of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Red Knobs formation in Tennessee: 3 miles east of Knoxville.

Discussion.—This species abundant in the Effna formation, is generally of small size and delicately costellate. It resembles *O. gibbosa* in form but is more delicately ornamented and has less deep valves. It differs from *O. parva* in having a deeper brachial valve and finer ornamentation. *Oxoplecia monitorensis* is larger, has a wider sulcus, stronger costellae, and a more transverse outline.

Oxoplecia holstonensis, like *O. gibbosa*, has variable ornamentation. This seems to be a matter of preservation, but it is difficult to be certain about the point. Some specimens appear to be nearly smooth, but the costellae are usually perceptible. In other specimens the costellae are well developed and strong, and the entire surface is covered by fila. The fact that fila are not visible on the smoother shells suggests that the ornamentation was worn away. This fact is confirmed by the common occurrence of this species in calcarenite matrix or lime-sands. This is an environment of rapidly moving water which would abrade the shell against the lime sand particles.

OXOPLECIA MAGNAPLICATA Cooper, new species

Plate 108, I, figures 43-48

Large for the genus; outline rectangular with narrowly rounded cardinal extremities, gently rounded sides, and somewhat narrowly rounded anterolateral extremities; anterior margin straight. Hinge wide; strongly uniplicate; strongly costellate. Costellae irregular, thick and rounded, 6 to 9 on the flanks, 4 on the fold, 3 in the sulcus on the type, but with anterior intercalations more may be counted on other specimens.

Pedicle valve evenly and gently convex in lateral profile; anterior broadly and gently convex. Umbo narrowly convex, small; sulcus originating 2 to 2½ mm. anterior to the beak, deepening rapidly to the front margin where it occupies less than half the shell width. Sulcus bounded by a prominent elevated plication occupied by 2 or more costellae; flanks gently concave. Interarea long, moderately apsacline.

Brachial valve gently convex in lateral profile with the umbo swollen but not strongly protruberant; anterior profile broadly and gently convex. Umbo swollen and small; fold originating on the anterior side of the umbo, elevating rapidly toward the front margin where it is high and with precipitous sides. Sulci at base of folds moderately deep and prominent, producing narrow lobes. Flanks gently swollen; posterolateral extremities somewhat flattened to perceptibly concave.

Measurements in mm.—Holotype, length 15.5, brachial length 13.9, width 21.2, hinge width 15.9, thickness 9.6.

Type.—Holotype: 117109.

Horizon and locality.—Shippensburg formation (Pinesburg member—*Echino-sphaerites* zone) in Maryland: Road cut on U. S. Highway 40 at Wilson on the west side of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—This species may be recognized by the strength of the costellae, the fairly narrow and elevated fold, and deep sulcus. The species is broadly shouldered but its profile somewhat compressed. It differs from *O. simulatrix* (Bassler), which has a high fold, in the greater strength of the costellae and in the less rotund profile. *Oxoplecia pennsylvanica* is strongly costellate and approximately the same size as *O. magnaplicata*, but it has more convex valves, lesser width, and a deeper sulcus.

OXOPLECIA MARMORATA Cooper, new species

Plate 103, B, figures 13-16

Shell of small to medium size for the genus, wider than long and with a broadly elliptical outline; sides narrowly rounded; anterior margin broadly rounded; surface strongly and completely costellate; numerous costellae bifurcating near the front margin; flanks with as many as 15 costellae; sulcus with 3 to 6 and fold with 4 to 7 costellae.

Pedicle valve moderately convex in lateral profile and broadly and gently convex in anterior profile; umbo narrow; sulcus originating 2 to 3 mm. anterior to the beak, wide and shallow, and occupying at least half the width. Flanks flat and with gentle slopes.

Brachial valve moderately convex in lateral profile but fairly strongly convex in anterior view; umbo swollen; fold broad and gently rounded, not strongly separated from the flanks, only gently elevated. Flanks inflated and with steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 8.0 | ? | 10.0 | 6.5 ? | 1.8 |
| Paratype (" " 117110b).... | 8.8 | ? | 10.4 | 7.5 ? | 1.2 |
| " (brachial valve 117110c)... | ? | 8.0 | 10.2 | 7.6 ? | 3.0 |
| " (" " 117110d)... | ? | 8.2 | 13.1 | ? | 3.0 |

Types.—Holotype: 117110a; figured paratypes: 117110b,c,e; unfigured paratype: 117110d.

Horizon and locality.—Red Knobs formation in Tennessee: 1 mile south of Louisville, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This is a small species so far known only from a "marble" facies. It reminds one somewhat of *O. holstonensis* but is more strongly costellate and with a wider outline. It is somewhat suggestive of *O. eidsonensis* in the exterior markings, but that species is larger and more robust with a strongly convex brachial valve. The costellae also suggest *O. recta*, but that species has a much flatter pedicle valve and a more strongly convex brachial valve.

OXOPLECIA MONITORENSIS Cooper, new species

Plate 102, D, figures 33-37

Shell of about medium size for the genus, wider than long, with a narrow hinge and somewhat narrowly rounded sides. Front margin truncated. Tongue short and broadly rounded. From 8 to 10 costae on the flanks, and 6 in the sulcus.

Pedicle valve gently convex in lateral profile; broadly and gently convex in anterior profile; umbo somewhat swollen. Sulcus originating 2 mm. anterior to the beak, wide and shallow, occupying about half the width. Flanks bounding sulcus slightly convex and with moderately steep posterolateral slopes. Interarea short, curved, apsacline; beak short.

Brachial valve moderately convex in lateral profile but with a swollen umbo; anterior profile strongly arched. Fold poorly defined on the median region, becoming elevated moderately at the front. Flanks moderately swollen and with steep slopes to the margins.

Measurements in mm.—Holotype, length 11.6, brachial length 11.7, width 15.0, hinge width 9.7, thickness 8.0.

Types.—Holotype: 117111a; unfigured paratypes: 117111b,c.

Horizon and locality.—Yellow limestone above the 25-foot bed of sandstone marking base of Eureka group, in Nevada: On the saddle just north of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This is a small rotund type of *Oxoplectra* suggestive of *O. holstonensis* and *O. parva*. It is, however, slightly larger than both of these species. It is also more strongly costellate than *O. holstonensis* and has a much less convex brachial valve, a much deeper sulcus, and a somewhat wider fold. The costellae of *O. parva* are somewhat stronger than those of the Nevada species, and its brachial valve is less strongly umbonate but is more convex.

OXOPLECIA MULTICOSTELLATA Cooper, new species

Plate 105, A, figures 1-27; plate 106, E, figures 25, 26

Shell large, roundly elliptical in outline; sides broadly rounded; anterior margin trilobate; valves unequally convex, the brachial valve having the greater depth; hinge narrow; uniplicate; multicostellate; flanks with 14 to 19 costellae; fold with 8 to 11 and sulcus with 7 to 10 costellae. Surface strongly filose, fila distant on body of shell, closely crowded at the margins.

Pedicle valve with unevenly convex lateral profile, the posterior half having the greater convexity and the anterior half somewhat flattened. Anterior profile broadly and moderately convex. Umbo strongly convex; sulcus originating 5 to 6 mm. anterior to the beak, shallow and poorly defined in the median region but deepening toward the front to attain about half the shell width. Sulcus bounded by a narrow plica in its anterior third; flanks bounding sulcus flat to gently concave and with gentle slopes. Interarea curved, apsacline.

Brachial valve with greatest curvature in the umbonal region which is strongly arched and is almost level with the pedicle beak; anterior profile strongly arched, but with only moderately steep slopes. Umbo swollen; median region swollen. Fold originating 6 to 7 mm. anterior to the beak, low and inconspicuous on the median part but fairly strongly elevated in the anterior region where it forms a lobate projection. Flanks somewhat swollen and steep posterolateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 19.9 | 19.2 | 23.0 | 12.4 | 12.9 |
| Paratype (117114a) | 18.9 | 18.5 | 24.7 | 11.6 | 14.1 |
| " (11791c) | 18.5 | 17.7 | 21.3 | 12.8 | 11.9 |

Types.—Holotype: 111790; figured paratypes: 111791a,d-f, 117112, 117113a-c, e,h,j, 117114a, 123334; unfigured paratypes: 111791b-c,g-i, 117113d,f,g,i,k-p, 117114b.

Horizon and locality.—Benbolt formation in Virginia: 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; west slope of the hill $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle; on Virginia Highway 74, 0.2 mile southwest of New Bethel Church, $\frac{1}{2}$ mile east of the junction with U. S. Highway 54, Hilton (T.V.A. 197-NW) Quadrangle; $\frac{1}{2}$ mile southeast of Richpatch, Eagle Rock (15') Quadrangle; just east of meridian $17^{\circ}30'$ east of Moccasin Creek, north edge of Mendota (T.V.A. 197-NE) Quadrangle; Virginia State Highway 80, $\frac{1}{2}$ mile south of Rockdell, Elk Garden (T.V.A. 212-NW) Quadrangle; Fugates Hill, 2 miles N. 45° W. of Mendota, Bristol (30') Quadrangle; $\frac{1}{2}$ mile northeast of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; Green Valley, 3 miles south-southwest of Lebanon, Brumley (T.V.A. 205-SE) Quadrangle; north side of U. S. Highway 19, $1\frac{3}{4}$ miles southeast of Hansonville Post Office, Brumley (T.V.A. 205-SE) Quadrangle.

Benbolt formation in Tennessee: On the north side of the road 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle; Grayson Farm, 4 miles southwest of Bland, Bland County; on Virginia Highway 113, Marion-Chatham Hill Road, 6 miles north of Marion, Chatham Hill (T.V.A. 218-NE) Quadrangle; 150 feet above the black beds in Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Sevier shale in Tennessee: $\frac{1}{4}$ mile along the wagon road northwest of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Edinburg formation (*Cyrtonotella* bed) in Virginia: Along Tumbling Run $1\frac{1}{2}$ miles southwest of Strasburg, Strasburg (15') Quadrangle; ravine at switch $\frac{1}{8}$ to $\frac{1}{4}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle; Colliers Creek, $\frac{1}{2}$ mile north of the junction of Virginia Highways 251 and 612, west-southwest of Lexington, Rockbridge County; Hiatt Run, 200 yards east of U. S. Highway 11, 3 miles north of Winchester, Winchester (15') Quadrangle.

Discussion.—This species is characterized by its large size and its numerous fine costellae. It attains the largest size of any species occurring in the Appalachian Valley. This species is quite suggestive of *O. gouldi* Ulrich and Cooper, but it does not attain the size of the largest specimens of the Oklahoma species. It is also somewhat more convex on the brachial side, has a narrower and more elevated fold, and is more umbonate in the brachial valve. The pedicle beak of *O. gouldi* is more incurved than that of *O. multicostellata*, and the ornamentation is somewhat finer.

Oxoplecia multicostellata is similar to *O. nevadensis* but differs in its somewhat finer costellae, its somewhat larger proportions and more rounded outline. It has a more inflated umbonal region than the Nevada form and a less erect pedicle beak. *Oxoplecia simulatrix* is another large species with which *O. multicostellata* might be confused, but it has different proportions, being a wider shell, and also is more strongly costellate.

OXOPLERIA NEVADENSIS Cooper, new species

Plate 102, E, figures 38-49

Large for the genus, transversely and broadly elliptical in outline; sides somewhat narrowly rounded; anterior margin nearly straight; costellate; sulcus with 5 to 6 costellae, fold with 6 to 7, and flanks with 11 to 12. Intercalations irregular.

Pedicle valve moderately convex in lateral profile and with the posterior portion somewhat swollen; anterior profile gently convex. Umbo smooth, sulcus originating abruptly at the anterior side of the umbo about 4 mm. anterior to the beak; sulcus deep and narrow, occupying about one-third to one-half the width at the front margin; flanks flat to gently convex and with moderate slopes. Interaea long, curved, apsacline.

Brachial valve moderately convex in lateral profile and with moderately swollen umbo; anterior profile strongly convex. Fold originating on the umbo, fairly strongly elevated to the anterior margin and with abrupt sides; flanks moderately swollen and with moderately steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 16.7 | 15.3 | 21.8 | 16.9 | 10.8 |
| Paratype | 15.7 | 15.2 | 20.0 | 13.0 | 11.7 |

Types.—Holotype: 117115a; figured paratype: 117115b.

Horizon and locality.—Eureka group (upper part of dark gray shale under the Eureka quartzite) in Nevada: On the north-facing nose of hill 8167 on Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This is the largest of the species so far found in the Roberts Mountains area. It is characterized by moderately strong costellae, a moderately widely elliptical outline, and fairly strongly elevated fold and deep sulcus. Comparison with *O. multicostellata* of the Appalachians is made under the description of that species. The Nevada form is suggestive of *O. simulatrix* and occupies a similar stratigraphic niche. It differs from that species, however, in having a narrower fold and sulcus, and finer costellae.

OXOPLECIA OCCIDENTALIS (Butts)

Plate 101, C, figures 16-22

Cliftonia occidentalis BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 126, pl. 31, figs. 21, 22, 1926.

The type lot consists of three specimens, one of which (71529c) is a young distorted pedicle valve too poor for description. The remaining two are a young pedicle valve and an adult brachial valve. The former is nearly circular in outline but with the width slightly greater than the length. The sulcus originates slightly more than one-third the length anterior to the beak, is shallow throughout its length. At the front margin the sulcus occupies about one-third the width of the valve. Flanks flattened, with moderately steep slopes to the margins. Umbonal region strongly convex in profile with strongly incurved beak. Sulcus with 5 costellae, flanks with 14 costellae.

Brachial valve slightly wider than long, gently convex in lateral profile but with a narrowly convex umbo. Fold originating just anterior to the umbo, slightly elevated at the front margin, and occupied by 7 costellae. Flanks convex, with steep slopes to form a narrowly rounded shell in anterior profile. Flanks with 14 costellae. Beak low, not protruding beyond the posterior margin.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------------------|--------|-------|-----------|
| Lectotype (brachial valve)..... | 16.0 | 17.2 | 6.6 |
| Paratype (pedicle valve 71529b)..... | 12.5 | 14.6 | 3.9 |

Types.—Lectotype: 71529a; paratypes: 71529b,c; figured hypotypes: 117116a,b.

Horizon and locality.—The published locality of this species is "Basal Chickamauga limestone, probably Ridley horizon, old quarry half a mile northeast of Gate City," Ala. This is evidently an error because a label in Dr. Butts' handwriting with other Alabama specimens reads "1½ miles northwest of Swansea

(Ireland).” The horizon of these specimens was referred to the Black River by Ulrich in his report on fossils collected for the Birmingham folio. It is probable that this last locality, too, is an error.

The type specimens of *O. occidentalis* are identical with ones from Oklahoma. Not only are the specimens identical with the Oklahoma forms, but the matrix is like that of parts of the Bromide limestone. The resemblance is so strong that it led Ulrich to pencil a note on the type label, as follows: “Probably Black River age and not Ridley. See small *Hallina*-like brachiopod. This and the *Cliftonia* probably same as the Oklahoma Criner species.” Oklahoma specimens, therefore, evidently were inadvertently labeled from Gate City, Ala.

The specimens herein illustrated were taken 149 feet below the top of the Bromide formation (Pooleville member?) in Oklahoma: In the section $\frac{1}{4}$ mile west of U. S. Highway 77, $3\frac{1}{2}$ miles north of Springer, Carter County; another lot of the same type of material was collected by C. A. Reeds in the section along Spring Creek, SW $\frac{1}{4}$ sec. 6, T. 2 S., R. 1 W., east of Pooleville, Murray County, and was taken from the heavy ledge in the creek above the 5th sandstone.

Discussion.—The species under discussion is represented by poorly preserved specimens which were broken from matrix and are therefore so exfoliated that details of the ornamentation are obscure. All the specimens despite this are well rounded in outline. In this respect they are very different from *O. gouldi*. They are more rounded than the young of *O. gouldi* and have more convex valves than specimens of *O. gouldi* of comparable size. No other species is quite like this one.

OXOPLECIA PARVA Cooper, new species

Plate 102, B, figures 18-24; plate 106, C, figures 12-16

Shell small for the genus, roundly elliptical in outline with the lateral margins broadly rounded and the anterior margin nearly straight; costellate, costellae variable, strong to subdued, often absent on parts of the shell; 8 on the flanks at the front margin. Fold with 4 or 5, and the sulcus usually with the same variation.

Pedicle valve unevenly convex, with the maximum convexity just anterior to the umbo; anterior profile broadly but faintly convex; sulcus originating on the anterior side of the umbo about 4 mm. anterior to the beak; sulcus deepening rapidly anteriorly to occupy slightly more than half the shell width at the front margin; flanks bounding the sulcus nearly flat; slopes gentle. Hinge narrow, interarea short.

Brachial valve strongly convex in lateral profile and with the most convexity in the umbonal region; anterior profile strongly arched and with long, steep lateral slopes. Umbo smooth and swollen; fold originating slightly posterior to the middle, fairly strongly elevated anteriorly. Flanks swollen and convex.

Measurements in mm.—Holotype, length 11.0, brachial length 10.3, width 12.3, hinge width 7.3?, thickness 7.6.

Types.—Holotype: 117118; figured paratypes: 117117a,b; unfigured paratype; 117117c.

Horizon and locality.—Benbolt formation in Virginia: On east bank of a sink-hole 300 feet south of Lakeview Church on Virginia Highway 71, Moll Creek (T.V.A. 196-SE) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, 1½ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Discussion.—This is a rare species in the Benbolt formation, where it occurs with the large *O. multicostellata*. The *O. parva* is typified by its small size and rotund form. In these respects it is like *O. holstonensis*, but its ribbing is too strong to be confused with that species. It is narrower, more rotund, and more strongly costellated than *O. planiventra* and *O. recta*.

OXOPLECIA PENNSYLVANICA Cooper, new species

Plate 104, C, figures 12-19

Shell of about medium size for the genus, wider than long, broadly subelliptical in outline with rounded sides and short hinge. Strongly uniplicate. Flanks marked by 7 to 9 broad, subangular to rounded costae with intercalations near the anterior margin; fold marked by 4 strong costae; sulcus marked by 3 major costae.

Pedicle valve moderately convex in lateral profile and with the maximum curvature just posterior to the middle; anterior profile fairly strongly convex. Umbonal region swollen; sulcus originating 2 to 3 mm. anterior to the beak, narrow and deepening anteriorly; tongue moderately long and narrowly rounded; flanks bounding sulcus flattened to gently convex and with steep lateral slopes.

Brachial valve fairly evenly and fairly strongly convex in lateral profile and with the umbonal region the most inflated part; anterior profile fairly strongly convex; fold originating on the anterior side of the umbo, narrow and fairly strongly elevated anteriorly where its sides are steep. Flanks moderately swollen and with steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.4 | 10.0 | 12.9 | 7.4 | 8.1 |
| Paratype | 13.9 | 12.7 | 15.5 | ? | 9.0 |

Types.—Holotype: 117119a; unfigured paratype: 117119b.

Horizon and locality.—Dark shale originally referred to Rodman member of the Nealmont formation but now called Salona formation (base) in Pennsylvania: At Bellefonte, Bellefonte (15') Quadrangle; ½ mile north-northwest of Oak Hall, Bellefonte (15') Quadrangle; old quarry 1 mile north-northeast of Bellefonte, Bellefonte (15') Quadrangle; ½ mile north of Roaring Springs, Holidaysburg (15') Quadrangle.

Discussion.—This species is one of the strongly costellated forms. It suggests *O. magnaplicata* more than any other species, but it is less umbonate and less convex in the brachial valve and has a more erect beak on the pedicle valve and a longer interarea.

OXOPLECIA PLANIVENTRA Cooper, new species

Plate 102, C, figures 25-32

Shell of about medium size for the genus, transversely elliptical in outline with narrowly rounded sides and gently rounded anterior margin. Hinge moderately wide. Pedicle tongue short, broadly rounded. Broadly uniplicate. Greatest width at or near the middle. Fold marked by 5 or 6 costellae, sulcus by 5 or 6 and the flanks by about 12 costellae, those of the posterolateral areas low and indistinct. Fila strong, about 5 to the millimeter in the middle.

Pedicle valve slightly to gently convex in lateral profile; anterior profile broadly and barely convex; umbo gently inflated; sulcus originating about 2 mm. anterior to the beak, broad and shallow throughout. Flanks bounding sulcus flat to gently convex and with gentle slopes to the margins. Interarea moderately long, curved, apsacline. Beak moderately long.

Brachial valve fairly evenly and strongly convex in lateral profile and with the maximum convexity located near the middle. Anterior profile strongly arched; umbonal region swollen; fold not strongly elevated in the median region but only gently elevated in the anterior region. Flanks bounding fold only gently inflated but with steep slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.6 | 9.6 | 14.2 | 8.3 | 6.6 |
| Paratype (117121a) | 10.3 | 9.2 | 13.1 | 7.7 | 6.8 |

Types.—Holotype: 117120; figured paratype: 117121a; unfigured paratype: 117121b.

Horizon and locality.—Sevier formation in Louisville (T.V.A. 138-SE) Quadrangle, Tennessee: $\frac{1}{4}$ mile northeast of Miser; $\frac{1}{4}$ mile north of Gooseneck.

Discussion.—This is one of the numerous small species of *Oxoplecia* occurring in the interval between the Lenoir and Benbolt. It is specially characterized by the flatness of the pedicle valve in both profiles. This feature distinguishes it from all the other small species except *O. recta*. That species has a more erect beak on the pedicle valve, a not quite so flat pedicle valve, a more umbonate brachial valve, and a generally rounder outline.

OXOPLECIA PLANULATA Cooper, new species

Plate 104, D, figures 20-24

Shell large for the genus, subquadrate in outline; sides broadly and gently rounded; anterior margin lobate; hinge narrow. Costellae broad and irregular, 11 to 13 on the flanks, 6 on the fold, and 5 in the sulcus. Fila closely crowded, about 8 to the millimeter at the middle of the brachial valve.

Pedicle valve gently convex in lateral profile and with a moderate swelling in the umbonal region. Anterior profile broadly and gently convex; sulcus originating 5 mm. anterior to the beak, narrow in the median region but flaring somewhat toward the front. Sulcus occupying less than half the width at the front

margin. Tongue short and broadly rounded. Plicae bounding sulcus moderately strong; flanks nearly flat and with gentle slopes. Interarea long, gently apsacline.

Brachial valve gently and evenly convex in lateral profile but with a swollen umbonal region; anterior profile broadly and gently convex. Fold originating just anterior to the umbo, low and narrow, expanding anteriorly; fold only moderately elevated above the flanks, most strongly elevated at the front. Flanks gently inflated and with moderate slopes to the margins.

Measurements in mm.—Holotype, length 21.4, brachial length 19.0, width 24.0, hinge width 14.3, thickness 10.0.

Type.—Holotype: 117122.

Horizon and locality.—Carters formation (*Oxoplectia* bed) in Alabama: In the quarry 0.3 mile north of Gate City, Leeds (15') Quadrangle.

Discussion.—This is a large species with strong costellae but it differs markedly from all the other large forms described herein in the strongly erect beak of the pedicle valve, the long interarea, and the shallowness of both valves. The species has an exceptionally compressed profile for such a large form.

OXOPLECTIA PLICATA Cooper, new species

Plate 104, E, figures 25-31

Shell small for the genus, transversely elliptical in outline with narrowly rounded lateral margins and broadly truncated anterior margin. Hinge wide, equal to more than half the shell width. Surface costellate, the sulcus occupied by 4 costellae and the fold by 6. Flanks marked by about 18 costellae.

Pedicle valve gently convex in lateral profile with the greatest curvature in the umbonal region. Beak prominent, elongated; posterior median half of valve gently convex; sulcus originating at about the middle, deepening rapidly and occupying about half the width at the front margin. Slopes into sulcus deep and abrupt; flanks bounding sulcus gently convex with gentle slopes to the margins; slopes to cardinal extremities steeper than those to margins but gentle nevertheless. Ridge on pseudodeltidium prominent; interarea curved, apsacline.

Brachial valve strongly convex in lateral profile, about three times as deep as the pedicle valve. Fold originating about one-third the length from the beak; umbonal region slightly swollen; beak low and inconspicuous. Fold strongly elevated in the anterior portion with steep and abrupt slopes to the flanks, which are strongly convex and have steep slopes to the margins.

Measurements in mm.—Holotype, length 9.1, brachial length 8.7, width 11.8, hinge width 7.0, thickness 7.1.

Type.—Holotype: 117123.

Horizon and locality.—Red Knobs formation in Tennessee: $\frac{3}{4}$ mile east of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This species is characterized by its small size, narrowly and transversely elliptical outline, and fine costellae. It has some of the features of small specimens of *O. holstonensis* but is wider and more distinctly marked.

OXOPLECIA RECTA Cooper, new species

Plate 104, A, figures 1-6

Shell small for the genus, slightly wider than long; often somewhat distorted; sides somewhat narrowly rounded; anterior margin truncated; widely uniplicate; hinge moderately wide. Surface strongly costellate; costellae numbering about 13; fold and sulcus with 5 to 8 costellae. Fila strong, numbering 5 to the millimeter in the middle of the pedicle valve.

Pedicle valve gently convex in lateral profile with the region between the middle and the beak somewhat swollen; anterior profile gently and broadly convex; beak long and pointed; unbo somewhat flattened; sulcus originating about 3 mm. anterior to the beak; sulcus broad and moderately deep, occupying more than half the width at the front margin. Tongue long and broadly rounded. Flanks bounding sulcus flattened and with little slope to the margins. Interarea long, curved, apsacline.

Brachial valve moderately convex in lateral profile; strongly arched in anterior profile: Fold wide but low and rounded; flanks bounding fold gently inflated but with moderate lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.9 | 10.3 | 13.4 | 8.8 | 7.1 |
| Paratype (117124) | 12.6 | 10.6 | 13.9 | 9.2 | 7.3 |

Types.—Holotype: 110849a; figured paratype: 117124; unfigured paratypes: 110849b,c.

Horizon and locality.—Lincolnshire formation (Hogskin member), in Tennessee: On Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 0.4 mile northeast of Red Hill, $4\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; school at Chesney, 2 miles northeast of Luttrell, Luttrell (T. V. A. 155-NW) Quadrangle.

Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species is most similar to *O. planiventra*. The differences between them are discussed under that species.

OXOPLECIA SIMULATRIX (Bassler)

Plate 101, A, figures 1-10; plate 101, B, figures 11-15

Triplecia (*Cliftonia*) *simulatrix* BASSLER, Cambrian and Ordovician: Maryland Geol. Surv., p. 266, pl. 49, figs. 11-13, 1919.

Shell of large size, transversely elliptical in outline with the length equal to about three-fourths the width. Lateral margins narrowly rounded, anterior margin truncated. Width of hinge slightly more than half the shell width. Surface strongly multicostellate, with the sulcus occupied by 6 to 9 costellae and the fold by 7 to 10. Flanks marked by 15 to 18 low, rounded costellae separated by

interspaces of about the same width as the costellae. Concentric fila numerous, about 5 in 1 millimeter near the middle.

Pedicle valve moderately convex in lateral profile and with the greatest convexity in the umbonal region; sulcus originating 3 to 4 mm. anterior to the beak, widening gradually to the front margin where it occupies about one-half the width. Flanks bounding sulcus flattened, slopes to lateral margins moderately steep. Tongue moderately long, broadly rounded. Beak low, strongly incurved; interarea moderately long; apsacline.

Brachial valve moderately convex in lateral profile but with a narrowly rounded umbo; anterior profile broadly and moderately convex; beak small, protruding slightly beyond the posterior margin. Fold originating on the strongly curved umbo, heightening anteriorly but only moderately elevated at the front margin. Flanks moderately convex but with steep slopes to the margins.

Interior: Pedicle valve with nearly obsolete dental plates, and delthyrial cavity nearly filled with callus; foramen functional, minute; diductor scars flabellate. Brachial valve with long, curved cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Lectotype | 8.8+ | 8.7+ | 12.8 | ? | 6.4 |
| Hypotype (117127) | 12.2 | 11.0 | 15.1 | 10.0 | 9.5 |
| " (97599a) | 17.0 | 16.3 | 22.5 | 15.5 | 14.1 |

Types.—Lectotype: 66175; figured hypotypes: 97599a, 117127; figured paratype: 117128.

Horizon and locality.—Lectotype from Chambersburg (*Sinuities* bed) (=Oranda in part) in Pennsylvania: 1 mile south of St. Thomas, Mercersburg (15') Quadrangle; 1 mile north of Guilford Springs, 2½ miles southwest of Chambersburg; 3½ miles north of Greencastle, Chambersburg (15') Quadrangle; Carlisle, Carlisle (15') Quadrangle.

Oranda formation in Virginia: Along the railroad ½ mile west of Strasburg; U. S. Highway 11, 2 miles southeast of Strasburg; on Virginia Highway 55, 0.4 mile west of U. S. Highway 11, north edge of Strasburg, Strasburg (15') Quadrangle; north of the road 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle; Strickler Farm, junction of Virginia County Highways 961 and 962, west of Edinburg; below the dam on the north branch of the Shenandoah River, 1½ miles north of Edinburg; on Bowman Farm, east of U. S. Highway 11, about 1 mile south of Woodstock, Edinburg (15') Quadrangle; 1½ miles east-northeast of Long Glade; just west of the junction of Virginia County Highways 617=910, and 777, 900 feet north-northwest of Green Mount Church, Broadway (15') Quadrangle; Cedar Grove Church, 200 yards on Virginia County Highway 616 east of U. S. Highway 11, 3½ miles southwest of Mount Jackson, Mount Jackson (15') Quadrangle.

Discussion.—The type lot of this species consists of four cotypes. Examination of the specimens makes it clear that they come from different strata and that they are not the same species. One of the cotypes (pl. 49, fig. 11.) is said

to have come from the *Sinuities* bed at the base of the Martinsburg shale, 1 mile south of St. Thomas, Pa. Although this specimen is a badly exfoliated interior filling and an immature specimen, it is nevertheless selected as lectotype. No other choice is possible because the remaining three specimens are all of dubious value.

The specimens illustrated by figures 12 and 13 on plate 49 are very poorly preserved and are evidently derived from a shaly matrix. The specimen shown in figure 12 is a fragment of a brachial valve showing the umbonal part and the brachiophores but not preserving the cardinal process. The figure is approximately natural size. The specimen illustrated by figure 13 is a complete specimen but is badly crushed. The illustration is approximately $\times 2$. These two specimens bear the catalogue number 66174. The label accompanying them reads: "Trenton (bed VII of section), Strasburg, Va." This bed according to Ulrich's notes corresponds to the lower Edinburg (*Cyrtototella* zone) of Cooper and Cooper. Thus these specimens have nothing to do with the lectotype which occurs hundreds of feet higher. These specimens are assigned somewhat doubtfully to *O. multcostellata* which is identified in the *Cyrtototella* beds in the vicinity of Strasburg.

The third cotype under number 66174 is another immature but complete specimen which is the best preserved one of both lots. It could not, however, be selected as the lectotype because its horizon and locality are equivocal even though it appears under the above number. This specimen is dark gray, lustrous, and gives the appearance of having come from the higher beds of St. Thomas or even of Strasburg. It resembles numerous specimens of the Oranda formation from Virginia more than it does those from the shaly beds of the lower Edinburg formation. This equivocal specimen is here referred to *O. simulatrix*, but its stratigraphic horizon is uncertain.

With reference again to the lectotype, it must be stated that the specimen is immature. The figure and its legend given by Bassler give no indication of the enlargement of the figure. The figure is actually approximately $\times 2$. The specimen is quite unlike the figure, which is retouched to such an extent that it is difficult to identify the specimen with it. The figure shows prominent costellae, and the sulcus occupied by 2 long and 2 short costellae. These give an entirely erroneous idea of the species because the lectotype is so exfoliated that only the stronger parts of the ornamentation are exhibited.

Confidence is here expressed that the lectotype is the young of the common *Oxoplecia* of the Oranda formation; therefore the name *simulatrix* is used for it. The above description is based on adult material from many localities and is thought to represent the species more accurately.

As defined herein *O. simulatrix* resembles some of the larger species found in the Appalachians. It is suggestive of *O. multcostellata* but differs importantly in its stronger ornamentation and profiles. Its differences from *O. nevadensis* are also in exterior details of ornamentation, fold and sulcus, and outline and profiles. It differs from *O. pennsylvanica*, which is approximately contemporaneous, in its less strong costellae and its more robust profiles.

Suborder SYNTROPHIOIDEA Ulrich and Cooper, 1936

Superfamily SYNTROPHIACEA Schuchert and Cooper, 1931

Family SYNTROPHOPSIDAE Ulrich and Cooper, 1936

Smooth or ribbed Syntrophiacea having long, convergent, subparallel septa in the brachial valve.

Genus RHYSOSTROPHIA Ulrich and Cooper, 1936

Rhysostrophia ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 630, 1936; Geol. Soc. Amer. Special Pap. 13, p. 240, 1938.

This genus is known from the high "Pogonip" of Nevada where it is represented by two species. It is also known from certain boulders in the Mystic conglomerate, which have produced two additional species. Its range is now extended to Newfoundland where it occurs in the Table Head series.

RHYSOSTROPHIA ELLIPTICA Ulrich and Cooper

Rhysostrophia elliptica ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 240, pl. 54C, figs. 5, 6, 1938.

Types.—Holotype: 91176c; paratypes: 91176a,b,d-f; 92883a,b.

Horizon and locality.—Mystic conglomerate in Stanbridge Township, Quebec, Canada: 2.6 miles north and $\frac{1}{2}$ mile east of Mystic, Range 6, Lot 21, and Range 6, Lot 20.

RHYSOSTROPHIA NEVADENSIS Ulrich and Cooper

Rhysostrophia nevadensis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 630, 1936; Geol. Soc. Amer. Special Pap. 13, p. 241, pl. 54D, figs. 9-11, 13-19; text fig. 10, 1938.

Types.—Holotype: 91172; paratypes: 92884a-e.

Horizon and locality.—Upper Pogonip group (*Rhysostrophia* zone) in Nevada: 1 mile above the mouth of Ikes Canyon, east side of Toquima Range, Roberts Mountains (1°) Quadrangle.

RHYSOSTROPHIA OCCIDENTALIS Ulrich and Cooper

Plate 112, B, figures 3-7

Rhysostrophia occidentalis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 630, 1936; Geol. Soc. Amer. Special Pap. 13, p. 242, pl. 54B, figs. 3, 4, 7, 8, 12, 1938.

Types.—Holotype: 91174; figured hypotype: 117163.

Horizon and locality.—Same as preceding.

RHYSOSTROPHIA TRANSVERSA Ulrich and Cooper

Plate 109, F, figures 30, 31

Rhysostrophia transversa ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 630, 1936; Geol. Soc. Amer. Special Pap. 13, p. 242, pl. 54A, figs. 1, 2, 1938.

Types.—Lectotype: 91175b; paratypes: 91175a,c.

Horizon and locality.—Mystic conglomerate in Quebec, Canada: Range 6, Lot 20, Stanbridge Township.

RHYSOSTROPHIA sp. 1

Plate 32, D, figures 7, 8

This is a small pedicle valve with deep sulcus and having a shallow spondylium. The ornamentation consists of narrowly rounded and closely crowded costellae. The specimen indicates a smaller species of the genus than hitherto seen in Nevada and one that is probably lower stratigraphically than the other known species.

Figured specimen.—17228.

Horizon and locality.—Pogonip group (*Desmorthis* zone) in Nevada: On the west side of Goodwin Canyon, Eureka District.

RHYSOSTROPHIA sp. 2

Plate 112, A, figures 1, 2

This is a small species with rectangular outline but not so strongly transverse as *R. transversa*. The specimens measure 7 to 8 mm. wide and 5 and 6 mm. long. The pedicle valve is deeply sulcate, and the brachial valve has a strong, elevated fold.

Figured specimens.—117162a,b.

Horizon and locality.—Table Head series (upper) in Newfoundland: At Table Point.

Family BREVICAMERIDAE Cooper, new family

Syntrophioidea having a sessile cruralium in the brachial valve.

BREVICAMERA Cooper, new genus(Latin *brevi*, short; *camera*, chamber)

Shell small, approaching $\frac{1}{2}$ inch in width; broadly and transversely elliptical; uniplicate; surface paucicostate. Biconvex; valves of subequal depth; hinge narrow; interareas reduced.

Pedicle interior with small teeth; spondylium short, dental plates short; median septum short.

Brachial interior with deep, narrow notothyrial cavity bounded by short subparallel brachiophore plates; brachiophores short, crescentic in section, tied to inner wall by short, inconspicuous fulcral plates. Brachiophores at place of articulation provided with a small articulating process opposite the fulcral plate. Brachiophore plates joining a callosity on the valve floor to form a sessile cruralium; floor callosity extended anteriorly between muscle scars as a low median ridge; muscle area small, divided into halves by the median ridge; posterior adductors small and narrow; anterior adductors large and subcircular, situated posterolaterally of the anterior scars.

Genotype.—*Brevicamera camerata* Cooper, new species.

Discussion.—The exterior features of this genus are suggestive of the syntrophids in the long tongue of the pedicle valve and the corresponding high and nar-

row fold, rather than recalling any members of the Camerellidae. Among the latter the transverse form is suggestive of *Parastrophina*, but usually the brachial valve of that genus is proportionately much deeper and more swollen than the pedicle valve. In these respects it is thus quite unlike *Brevicamera*.

Although the exterior of *Brevicamera* is not unusual, the interior characters are, especially those of the brachial valve. The spondylium of the pedicle valve presents no unusual features. It is small and narrow at the front, and the dental plates are short. Actually the whole structure is fairly small when compared to some other genera such as *Camerella* itself. The median septum is short and does not extend anterior to the spondylium. In this respect the genus is unlike most related genera. If one can judge by genera at the summit of the syntrophid line and of the Gypidulinae, abbreviation of the septum is an advanced character which appears late in a lineage.

The brachial valve is the one which gives definition and focus to the genus because no camerellid like it is known. The entire cardinalia are of interest. The brachiophores are short but somewhat bulbous opposite the socket. At this point they have a small process, directed obliquely toward the opposite valve, which must serve as an accessory articulating nub. The socket is defined in part by a small fulcral plate. The blade of the brachiophore is short and crescentic in section. Brachiophore plates are subparallel and extend nearly vertically to the floor of the valve where they join a callosity to form a sessile cruralium. The anterior end of the callosity is extended anteriorly to divide the small and confined muscle field into two parts. The sessile cruralium is quite unlike the brachial structure of any known genus although loss of median septum occurs in the peculiar genus *Plectocamera*.

Specimens of *Brevicamera* so far have been found only in the Pratt Ferry exposures in Alabama, and here they are rare indeed.

BREVICAMERA CAMERATA Cooper, new species

Plate 118, A, figures 1-10; plate 119, E, figures 15, 16

Small, transversely elliptical in outline; sides oblique, straight, forming an apical angle of about 120° . Sides narrowly rounded; anterior margin nearly straight. Valves convex, the brachial valve slightly deeper than the pedicle valve. Anterior commissure narrowly and steeply uniplicate. Surface smooth except for the anterior margin which is marked by a few costae, 2 on the flanks, 3 or 4 on the fold, and 2 in the sulcus, the latter confined to the tongue.

Pedicle valve gently convex in lateral profile but with the maximum curvature in the posterior half; anterior profile broadly and gently convex. Umbonal region narrowly swollen; median region inflated. Sulcus originating abruptly at the middle, fairly wide, deepening rapidly. Tongue geniculated at a right angle, long, narrow, and truncated at the front. Flanks bounding sulcus marked by a strong plica that extends indistinctly for some distance in a posteromedian direction. Flanks inflated and with steep slopes. Interior with short, narrow, and delicate spondylium. Interarea nearly obsolete.

Brachial valve gently convex in lateral profile but with a strongly inflated umbo; anterior profile broadly but strongly convex. Median region inflated, fold originating at the middle, narrow, strongly elevated. Flanks swollen, narrowly rounded, and depressed. Interior with sessile cruralium, short median ridge, and small adductor field.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (brachial valve)..... | ? | 7.3 | 9.2 | 1.9 | 2.2 ? |
| Paratype (pedicle valve 117154a). 6.1 | | ? | 9.4 | 2.0 | 2.0 ? |

Types.—Holotype: 117154c; figured paratypes: 117154a,b.

Horizon and locality.—About 3 feet above the base of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species of this genus is known to which *B. camerata* may be compared.

Family CAMERELLIDAE Hall and Clarke, 1894

Biconvex, narrow-hinged Syntrophiacea having a small cruralium duplex in the brachial valve; interareas reduced or obsolete.

Subfamily CAMERELLINAE Hall and Clarke, 1894

Camerellidae having a spondylium simplex in the pedicle valve.

Genus CAMERELLA Billings, 1859

Camerella BILLINGS, Canadian Nat., vol. 4, p. 301, 1859.

Rhynchocamara SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 189, 1932.

CAMERELLA ANTEROPLICATA Cooper, new species

Plate III, F, figures 46-54; plate III, G, figures 55-63

Shell of about medium size for the genus, slightly wider than long and with the greatest width at about the middle; outline forming a depressed oval; posterolateral margins straight, directed obliquely and forming an angle slightly more than 90°. Sides narrowly rounded; anterior margin broadly rounded; anterior commissure strongly uniplicate. Posterior half of shell smooth, anterior half costate with 2 to 3 costae on the flanks, 3 to 4 on the fold, and 2 to 3 in the sulcus.

Pedicle valve less deep than the brachial valve; gently convex in lateral profile with the maximum convexity slightly posterior to the middle; anterior profile broadly and gently convex; umbonal and median regions moderately inflated; sulcus short and shallow, originating just anterior to the middle; tongue short, serrate; flank bounding sulcus moderately swollen. Costa bounding sulcus stronger and more elevated than the others. Beak short, incurved, protruding slightly posterior to the brachial umbo.

Brachial valve fairly strongly and evenly convex in lateral profile and with

maximum convexity at about the middle; anterior profile strongly domed but crest of dome somewhat flattened; umbonal and median region strongly inflated; fold short and low.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.2 | 8.0 | 8.5 | 1.5 | 5.6 |
| Figured specimen | 7.0 | 6.9 | 7.0 | 1.6 | 4.7+ |

Types.—Holotype: 117129; figured specimen: 111341.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: At Rock Crossing, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—This species is characterized by its smooth posterior three-quarters or more and the strong anterior costation. The brachial valve is swollen, and the umbo is elevated almost flush with the beak of the pedicle valve. This species is very similar to *Camerella* sp. 3 from the Benbolt limestone in general appearance, but the latter is a somewhat wider shell with a less convex brachial valve and less produced umbo. The apical angle of the Oklahoma species is less than that of the Benbolt form, and the sulcus of the latter is deeper and originates nearer the middle.

CAMERELLA BELLA Fenton

Plate 112, C, figures 8-15

Camerella bella FENTON, Amer. Midland Nat., vol. 11, p. 136, pl. 3, figs. 1-12, 1928.

Shell of medium size for the genus, subpentagonal to suboval in outline, slightly longer than wide. Greatest width in the anterior third. Beak angle about 87° , defined by nearly straight posterolateral margins; lateral margins narrowly rounded. Anterior margin truncated. Surface costate; 2 or 3 costae occupy the sulcus, while 3 or 4 occur on the brachial fold. Flanks marked by 4 costae.

Lateral profile of pedicle valve with maximum curvature in the posterior third, the anterior two-thirds somewhat flattened. Anterior profile a depressed arch. Sulcus originating abruptly at $7\frac{1}{2}$ mm. anterior to the beak, shallow and widening slightly anteriorly to occupy a little more than half the width at the front margin. Tongue moderately long, truncated. Umbo somewhat swollen posteriorly but flattening anteriorly to the place of origin of the sulcus. Flanks moderately elevated above the sulcus anteriorly, slightly convex and with gentle slopes to the margins.

Brachial valve fairly strongly convex in lateral profile with the greatest curvature at the umbo; somewhat narrowly rounded in anterior profile. Umbonal and central region somewhat inflated. Fold originating about 6 mm. anterior to the beak, low and only slightly elevated above the flanks. Fold gently convex in profile. Flanks gently rounded but with very steep slopes to the margins. Anterior reentrant to receive tongue short.

Interior with a deep and fairly wide spondylium supported by a short septum

reaching to about the middle. Cruralium small and narrow, supported by a short septum.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (pedicle valve IIIIOIm).... | 12.7 | ? | 12.8 | 4.0 | 4.6 |
| " (brachial valve IIIIOIk)... | ? | 13.2 | 13.6 | 3.3 | 6.1 |
| " (" " IIIIOI-l) .. | ? | 13.8 | 13.2 | 2.9 | 9.7 |

Types.—Figured hypotypes: IIIIOIk,m, IIIIO2a; measured hypotype: IIIIOI-l.

Horizon and locality.—Plattin group (Macy formation) in Missouri: At the Heck Place, $1\frac{1}{4}$ miles south-southeast of River aux Vasses, Weingarten (15') Quadrangle; Pacific, Pacific ($7\frac{1}{2}'$) Quadrangle; northwest of Ste. Genevieve on the road to Bloomsdale, Renault (15') Quadrangle; 3 miles east of Auburn, Elsberry (15') Quadrangle; on the old road 1 mile northwest of the Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E., Weingarten (15') Quadrangle.

Carters limestone in Tennessee: Below the bentonite just east of Round Lick Creek on U. S. Highway 70N at Rome, Smith County; below the bentonite 0.8 mile east of Readyville on the north side of U. S. Highway 70S, Rutherford County.

Discussion.—This species is characterized by its fairly large size, strong folding, and the half costate exterior. The costation is like that of *Camerella plicata* (Schuchert and Cooper) in having 2 costae in the sulcus and 3 on the fold, but the costation extends to the middle whereas it is confined to the anterior third in *C. plicata*. Furthermore, the pedicle umbo of *C. bella* is more inflated and the fold of the brachial valve originates just posterior to the middle in *C. bella*.

CAMERELLA BICOSTATA Cooper, new species

Plate 106, H, figures 45-54; plate III, A, figures 1-15

Shell moderately large for the genus, wider than long with the greatest width slightly anterior to the middle. Beak forming an angle slightly greater than a right angle. Posterolateral margins widely divergent; anterolateral extremities narrowly rounded; front margin nearly straight. Surface with posterior half smooth, anterior half marked by 11 costae, 2 occupying the sulcus, 3 on the fold, and 3 or 4 on the flanks.

Pedicle valve slightly less deep than the brachial valve, gently convex in lateral profile with the most convex part just anterior to the umbo. Sulcus originating at about the middle, deepening abruptly but widening gradually anteriorly, where it occupies about half the valve width. Flanks flat to gently concave in profile and with gentle slopes.

Brachial valve gently convex in lateral profile and with the most convex part in the umbonal region; nearly semicircular in anterior profile. Fold not greatly elevated above flanks which are gently convex and slope steeply to the margins. Umbonal region moderately convex.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 11.2 | 10.3 | 13.7 | 7.4 |
| Paratype (111110a) | 12.7 | 11.6 | 13.9 | 7.9 |
| “ (111106) | 10.6 | 10.2 | 12.4 | 6.8 |

Types.—Holotype: 117130b; figured paratypes: 111106, 111110a, 117130a; unfigured paratypes: 111110b-d.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: In the *Sowerbyites* zone, on road to Thorn Hill, 0.4 mile east of Red Hill, SW $\frac{1}{4}$ NW subquad. of Avondale (T.V.A. 162-SW) Quadrangle; 2.1 miles southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; 1 mile southeast of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 3 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; 2 miles southwest of Hall Crossroad, NW $\frac{1}{4}$ center subquad. of Fountain City (T.V.A. 146-SW) Quadrangle.

Discussion.—This species is characterized by its fairly large size, 2 costae in the sulcus, and the lack of ornamentation on the posterior part. It differs from the bicostate *C. edmundsoni* in its larger size, less completely costate valves, and wider form. It differs from *C. plicata*, which it resembles in costation, by its different proportions, *C. bicostata* being wider than long.

CAMERELLA BREVIPLICATA Billings

Plate 115, E, figures 32-34

Camerella breviplicata BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 304, fig. 295, 1865.

Rhynchocamera breviplicata Billings, ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 251, 1938.

Type.—Holotype: G.S.C. 759.

Horizon and locality.—Boulder in Mystic Conglomerate in Quebec: In Range 6, Lot 20, Stanbridge Township.

Discussion.—This is one species of a group common in the upper part of the Canadian which has a strongly inflated brachial valve but a smaller pedicle valve and is costate only at the anterior.

CAMERELLA COSTELLATA Cooper, new species

Plate 112, G, figures 34-41; plate 118, C, figures 20-29

Shell fairly large for the genus, transversely and broadly elliptical in outline; posterolateral margins straight, forming an angle of about 110°; greatest width slightly anterior to the middle; lateral margins narrowly rounded; anterior margin gently rounded. Anterior commissure somewhat narrowly uniplicate. Beaks and umbos smooth, anterior two-thirds costellate, with about 20 to 27 costae at the anterior margin, 5 to 7 in the sulcus.

Pedicle valve evenly and strongly convex in lateral profile with the greatest convexity at about the middle; anterior profile broadly convex, with moderately

sloping sides. Sulcus shallow, originating about 9 mm. anterior to the beak and occupying about half the width. Floor of sulcus convex and with a short tongue. Flanks bounding sulcus moderately convex. Median septum supporting a narrow spondylium and extending to the center.

Brachial valve nearly as deep as the pedicle valve, moderately convex in lateral profile but with an inflated umbo; anterior profile strongly arched and with precipitous sides. Fold low and inconspicuous, originating at or near the middle; flanks swollen. Umbonal and median regions inflated. Cruralium short, moderately deep; septum short.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.7 | 12.3 | 14.9 | 4.0 | 10.2 |
| Paratype (pedicle valve IIII13a).... | 12.8 | ? | 13.6 | ? | 3.0 |
| “ (brachial valve IIII13b).... | ? | 11.3 | 14.4 | ? | 2.6 |

Types.—Holotype: 117131; figured paratypes: IIII13a,b.

Horizon and locality.—Elway formation in Tennessee: $\frac{3}{4}$ mile southwest of Mount Eager Church, Powder Springs (T.V.A. 154-SW) Quadrangle; U. S. Highway 25E, north of Evans Ferry, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Elway formation in Virginia: At Eggleston, Giles County.

Discussion.—This species is characterized by its broadly elliptical outline and the nearly completely costate shell. The species is suggestive of *C. elliptica*, but that species attains a considerably greater size and differs in having much more strongly defined costae, a more erect beak on the pedicle valve, and the sulcus originating posterior to the middle. *Camerella multiplicata* is another Elway species, but it is more triangular in outline and the ornamentation is more strongly etched into the shell.

CAMERELLA EDMUNDSONI Cooper, new species

Plate 115, F, figures 35-42; plate 115, I, figures 50-52

Shell small, pentagonal in outline, with the length slightly greater than the width. Greatest width at about the middle. Beak varying from a right angle to an acute angle. Lateral margins straight and divergent to the anterolateral extremities which are moderately rounded. Surface marked by closely crowded, rounded costae, 2 or 3 (occasionally 4) in the sulcus and 4 forming the fold. Flanks marked by 3 costae.

Pedicle valve evenly convex in lateral profile with the maximum convexity at about the middle; sulcus originating about one-third the length anterior to the beak, shallow, and occupying about half of the width. Tongue short, generally truncated. Umbonal region smooth, gently convex.

Brachial valve generally more circular in outline than the pedicle one and with length and width about equal, slightly deeper than the pedicle valve. Moderately convex in lateral and anterior profiles. Fold originating about one-third the

length from the beak, only slightly elevated above the flanks with are rounded and have steep slopes. Umbonal region moderately curved.

Interior: Spondylium of pedicle valve in length equal to about one-third the valve length; septum short and thin. Cruralium and septum of brachial valve short.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|----------------------------------|--------|-----------------|-------|-----------|
| Holotype (pedicle valve) | 10.6 | ? | 9.9 | 3.0 |
| Paratype (111117e) | 9.2 | ? | 8.4 | 3.9 |
| " (117132a) | 10.6 | ? | 10.1 | 2.6 |
| " (brachial valve 111117a) | ? | 9.8 | 10.2 | 4.6 |
| " (111117c) | ? | 10.2 | 10.9 | 4.2 |
| " (117132b) | ? | 10.4 | 10.3 | 4.4 |

Types.—Holotype: 111117b; figured paratypes: 111117a,c-e, 117132a,b.

Horizon and locality.—Poteet formation (Yellow Branch member) in Virginia: On the road along Yellow (Creek) Branch, 5 miles southeast of Rose Hill, Rose Hill (T.V.A. 161-NE) Quadrangle.

Discussion.—This species is recognized by its elongate form and the nearly complete costation of the surface. It most nearly resembles some of the variants of *C. plicata* in which the valves are almost completely costate and the sulcus is occupied by 3 costae, but differs from them in having a more elongate fold and sulcus. The costation is similar to that of *C. globularis*, but that species is more rotund in profile and is wider than long.

CAMERELLA ELLIPTICA Cooper, new species

Plate 113, E, figures 32-43; plate 113, F, figures 44-48

Shell large for the genus, wider than long with a broadly elliptical outline; beak forming approximately a right angle, sides narrowly rounded and front margin nearly straight. Surface marked by 18 subangular costae of which 5 occupy the fold and 4 occur in the sulcus. Flanks with 6 costae.

Pedicle valve moderately convex in lateral profile with the greatest convexity slightly posterior to the middle; beak short, slightly curved; umbonal region gently convex. Fold originating about one-fifth the length anterior to the beak, shallow and occupying slightly less than half the width at the front. Tongue short, slightly rounded. Flanks gently convex and sloping moderately to the margins.

Brachial valve slightly more convex than the pedicle valve in lateral profile and with the greatest convexity at about the middle. Anterior profile broadly but only moderately convex. Umbonal region strongly convex; fold low, only slightly elevated above the flanks which are moderately convex and slope steeply to the margins.

Interior: Spondylium in the pedicle valve long and slender, extending to a point slightly posterior to the middle. Cruralium of brachial valve short but with long brachial processes.

Measurements in mm.—Holotype, length 14.5, brachial length 13.4, width 16.4, thickness 10.3.

Types.—Holotype: 111119d; figured paratypes: 98220a, 111119b,c; unfigured paratypes: 98220b, 111119a; figured specimen: 117133a.

Horizon and locality.—Lincolnshire formation in Virginia: At Marcem Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle.

Lincolnshire formation in Tennessee: On the north side of the road, 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle.

Discussion.—Large size, completely costate surface, and great width are the features that serve to distinguish this shell from all others known. In its large number of costae it is suggestive of *C. multicosata* but is larger and of different proportions. Other described forms of such large size, such as *C. gregeri* and *C. volborthi*, are generally only partially costate.

This species is more strongly costate and more deeply sulcate than *C. costelata* from the Elway formation, which it resembles in outline and profile. It is distinguished from *C. globularis*, which it resembles in profile, by its more finely ornamented exterior and greater width.

Inside the brachial valve of one specimen the brachiophores are preserved in their entirety, proving to be long and slender processes extending in the direction of the brachial valve.

CAMARELLA GLOBULARIS Cooper, new species

Plate 116, B, figures 6-20; plate 116, C, figures 21-24

Camarella sp. BUTTS, Virginia Geol. Surv. Bull. 52, p. 45, pl. 74, figs. 1-7, 1942.

Shell of about medium size for the genus, transversely subelliptical in outline, and globular in profile. Sides strongly rounded, beak approximately a right angle. Surface of posterior third smooth, anterior two-thirds marked by 14 to 16 broadly rounded costae separated by spaces less wide than the costae. From 1 to 4 costae occupy the sulcus, and 4 to 5 mark the fold; flanks marked by 4 to 5 costae. Spondylium wide and deep.

Pedicle valve evenly and moderately convex with the maximum convexity at about the middle; sulcus originating at about the middle of the valve, shallow, and occupying somewhat more than half the valve width. Tongue short and truncated. Flanks moderately rounded in profile and with steep slopes.

Brachial valve considerably deeper than the pedicle one, strongly convex in lateral and anterior profile and with greatest convexity at the middle. Umbonal and posterior region swollen; fold originating at about the middle, low and rounded in profile. Flanks moderately rounded and with steep slopes. Brachial interior with small cruralium.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|--------------------|-------|-----------|
| Holotype | 13.3 | 12.6 | 14.8 | 11.8 |
| Paratype (98192a) | 12.2 | 10.8 | 12.4 | 9.6 |

Types.—Holotype: 117134; figured paratypes: 98192a,b; figured specimen: 117135.

Horizon and locality.—Whistle Creek formation on Lexington (15') Quadrangle, Virginia: On U. S. Highway 60, 100 yards southeast of Whistle Creek; 2 miles northwest of Lexington.

Discussion.—Characterized by globular profile and presence of 3 to 4 costae in the sulcus. Compared with *C. plicata*, which occasionally develops tricostate forms, this species proves to be wider and more globular. It also differs from *C. quadriplicata* Willard in possessing a more rounded profile and in having less numerous costae on the flanks. *Camerella globularis* also resembles *C. elliptica* but differs in its more convex profiles and the seminude exterior. *Camerella globularis* shows considerable variation in the number of costae present in the sulcus and on the fold. One specimen has a single costa in the sulcus, and others have from 2 to 4. The two higher figures seem to represent the normal condition.

CAMERELLA GREGERI Cooper, new species

Plate 113, D, figures 20-31

Shell large for the genus, slightly wider than long and having a pentagonal outline. Beak slightly greater than a right angle, anterolateral extremities narrowly rounded, anterior margin truncated. Greatest width anterior to the middle. Surface smooth in the posterior half, but marked by subangular and compressed costae with interspaces about as wide as the costae, 5 to 7 costae on the fold, 4 to 6 in the sulcus, and 5 to 6 on the flanks.

Pedicle valve slightly convex in lateral profile with the greatest convexity just anterior to the umbonal region. Sulcus originating at the middle, deepening abruptly and occupying one-half to two-thirds the width at the front. Tongue moderately long with a truncated extremity. Flanks gently convex and with gentle slopes to the margins. Spondylium wide and deep, septum reaching anterior to the middle.

Brachial valve about twice as deep as the pedicle valve, only moderately convex in lateral profile but strongly arched in anterior profile. Fold originating at the middle, truncated at the front and moderately elevated. Flanks rounded and with steep slopes. Umbonal region strongly convex. Cruralium small.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.8 | 17.6 | 19.1 | 4.7 | 14.5 |
| Paratype (111125) | 17.2 | 16.8 | 17.8 | 3.8 | 12.8 |

Types.—Holotype: 111126; figured paratypes: 111125, 117136a,c; unfigured paratype: 117136b.

Horizon and locality.—Plattin group (Macy formation) in Missouri near Glencoe, St. Louis County: Rockwoods Reservation, 20 miles west of Grover, St. Louis County; on Fredericktown road 5 miles southwest of Ste. Genevieve, Weingarten (15') Quadrangle.

Discussion.—This is the largest known species of *Camerella*, exceeding even *C. volborthi* in size. It is also characterized by having numerous costae on the fold and in the sulcus. These vary from 5 to 6 in the sulcus and 6 to 7 on the fold. The species is thus unlike any other described form.

CAMERELLA IMMATURA Cooper, new species

Plate 110, A, figures 1-5

Shell small, subpentagonal in outline, slightly wider than long; apical angle slightly greater than a right angle; sides narrowly rounded; anterior somewhat produced and truncated. Anterior commissure narrowly uniplicate; surface smooth except for 2 costae on the flanks.

Pedicle valve gently convex in lateral profile and with the maximum convexity at about the middle; anterior profile broadly and gently convex; median region inflated; sulcus originating in the anterior third and anterior to the inflated region; sulcus smooth, concave; tongue moderately long and narrow. Flanks gently convex and with moderate slopes.

Brachial valve deeper than the pedicle valve and gently convex in lateral profile with the umbo swollen. Anterior profile broadly and gently convex but with precipitous sides. Median region and flanks inflated. Fold short, narrow, slightly elevated, marked by a slight depression medianly.

Measurements in mm.—Holotype, length 5.5, brachial length 5.6, width 6.1, hinge width 1.7?, thickness 4.0.

Type.—Holotype: 117137.

Horizon and locality.—Chatham Hill formation in Virginia: On Grayson Farm, 4 to 5 miles southeast of Bland, Bland County.

Discussion.—This species is characterized by its nude exterior and the lack of costae in the sulcus and on the fold. No comparable species is available.

CAMERELLA INDEFINITA Cooper, new species

Plate 112, D, figures 16-22

Shell moderately large for the genus, slightly longer than wide with the greatest width slightly anterior to the middle. Beak forming an acute angle of about 80°; sides narrowly rounded and anterior margin gently rounded. Surface marked by 19 low, rounded costae separated by spaces narrower than the costae. Six costae occupy the sulcus, and 7 occur on the fold.

Pedicle valve gently convex in lateral profile with the most convex part slightly posterior to the middle. Sulcus poorly defined, originating at about the middle and occupying about two-thirds the valve width at the anterior. Flanks narrow, slightly convex but with steep slopes to the margins.

Brachial valve moderately convex with the greatest convexity slightly posterior to the middle. Umbonal region moderately convex, fold poorly defined, wide, originating slightly posterior to the middle. Flanks convex and with steep slopes.

Measurements in mm.—Holotype, length 13.7, brachial length 12.5, width 12.8, hinge width 3.2, thickness 8.9.

Type.—Holotype: IIII27.

Horizon and locality.—Elway formation, (35 to 55 feet above base of section) in Tennessee: $\frac{1}{2}$ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species is distinguished from all others known by its elongate form, narrow posterior, multiplicate shell, and the inconspicuous character of the fold and sulcus, neither of which is strongly set off from the surrounding parts of the shell. It is suggestive of *C. leiorhynchoidea* but is more strongly costate.

CAMERELLA ? LEIORHYNCHOIDEA Cooper, new species

Plate 114, D, figures 39-43

Shell of about medium size for the genus, all the specimens in a crushed state and simulating common *Leiorhynchus* (now *Nudirostra*); valves of nearly equal depth and convexity. Surface completely costate except for beak region which is smooth. Costae narrowly rounded, low, irregular. Greatest width anterior to the middle. Interior of both valves with a long median septum.

Measurements in mm.—

| | Length | Width |
|--|--------|-------|
| Holotype (pedicle valve)..... | 13.4 | 13.0 |
| Paratype (brachial valve 117138d)..... | 10.8 | 10.4 |

Types.—Holotype 117138a; figured paratypes: 117138b-d; unfigured paratypes: 117138e-h.

Horizon and locality.—Edinburg formation (Liberty Hall facies), just below a siltstone with *Paucicrura* in Virginia: On the south side of U. S. Highway 33 in pasture road, between Peales Crossroads and Penn Laird, about 5 miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle.

Discussion.—The material on which this species is based is not well enough preserved to determine whether or not the genus is *Camerella* or *Parastrophina*. It is referred doubtfully to *Camerella* because that is the commoner genus in the Appalachians. The species can be recognized by its similarity to *Leiorhynchus limitare*.

CAMERELLA MINUTA Cooper, new species

Plate 113, C, figures 10-19

Shell small for the genus, subpentagonal in outline with the length and width about equal. Beak angle slightly less than 90°. Posterolateral margins straight; lateral margins narrowly rounded with the greatest width located at about the middle. Anterior margin gently rounded. Surface costate in the anterior half, 2 costae in the sulcus, 3 on the fold, and 3 or 4 on the flanks. Costae thick, rounded.

Pedicle valve gently convex in lateral profile with the maximum convexity about one-third the length from the beak; anterior portion somewhat flattened. Posterior half somewhat swollen; sulcus originating about $2\frac{1}{2}$ mm. anterior to the beak at about the middle of the valve, widening anteriorly to occupy slightly more

than half the width at the front margin. Sulcus shallow, abruptly bent toward the brachial valve to form a short, blunt tongue. Costae bounding sulcus strongly subangular and prominent. Flanks slightly convex with moderately steep slopes. Median septum reaching nearly to the middle of the valve.

Brachial valve moderately convex in lateral profile with the unbonal region the most convex part. Anterior profile a narrowly rounded arch. Fold originating at about the middle, moderately elevated anteriorly with rounded depressed flanks, steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 4.9 | 4.5 | 4.8 | 3.4 |
| Paratype (IIII29a) | 5.6 | 5.1 | 6.5 | 4.1 |
| " (IIII28e) | 5.4 | 4.8 | 5.2 | 3.6 |

Types.—Holotype: IIII31a; figured paratype: IIII28e; unfigured paratypes: IIII28a-d, IIII29a-c, IIII30a,b, IIII31b.

Horizon and locality.—Effna formation in Virginia: At the McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Botetourt formation in Virginia: Near Cedar Grove Church and School, 1½ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle; 1 mile northwest of Lexington, Lexington (15') Quadrangle; 2 miles south of Hogback Mountain, 7 miles north-northeast of Lexington, Lexington (15') Quadrangle; Catawba Valley, at junction of Virginia Highways 114 and 311, ½ mile southwest of Catawba Valley, Salem (15') Quadrangle.

Chatham Hill formation in Bland County, Virginia: on Grayson Farm, 4 miles southwest of Bland; 6 miles southwest of Bland.

Discussion.—This species is characterized by its small size and the usual presence of 2 costae in the sulcus. The species is thus suggestive of members of the genus *Plectocamara*, but it differs from all of them in its partially nude ornamentation and the presence of long septa. It is quite unlike any other described species.

CAMERELLA MULTIPLICATA Cooper, new species

Plate 112, E, figures 23-29

Shell of about medium size for the genus, with length and width about equal; greatest width anterior to the middle, giving the shell a pentagonal outline. Anterior margin truncated. Apical angle about 90°. Anterior commissure uniplacate. Surface marked by subangular costae of which 4 or 5 occupy the sulcus, 5 or 6 are on the fold, and 9 on the flanks.

Pedicle valve moderately and evenly convex in lateral profile with the greatest convexity at about the middle. Sulcus originating about one-third the length from the beak, shallow, and occupying about half the width at the front. Tongue short, not strongly geniculated. Flanks gently convex with gentle slopes to the margins.

Brachial valve somewhat more convex than the pedicle valve in lateral profile

and with the greatest convexity at about the middle. Anterior profile strongly arched. Fold originating about one-third the length from the beak, low and gradually widening anteriorly. Umbo slightly swollen with incurved beak. Flanks narrowly convex and with steep lateral slopes.

Measurements in mm.—Holotype, length 11.6, brachial length 10.9, width 11.1, thickness 8.0.

Type.—Holotype: 111153.

Horizon and locality.—Elway formation in Tennessee: $\frac{1}{2}$ mile northeast of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Elway formation in Virginia: On Virginia Highway 71, 1 mile northeast of Dickensonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Whistle Creek formation in Virginia: On Virginia Highway 602, $5\frac{1}{2}$ miles S. 82° W. of Middlebrook, Augusta County.

Discussion.—This species is characterized by the numerous direct costae marking the surface of the valves. It differs from *C. indefinita* in having its shell more evenly and regularly costate and in possessing 5 costae in the sulcus instead of 6 as in *C. indefinita*. It differs from *C. elliptica* in the form of the valves, the latter being a much wider shell.

CAMERELLA NUDA Cooper, new species

Plate 115, C, figures 12-21

Shell small for the genus, slightly longer than wide; oval in outline; apical angle slightly greater than a right angle; greatest width at about the middle and with narrowly rounded sides; posterolateral margins sloping toward the middle; anterior margin truncated. Posterior two-thirds smooth; anterior third marked by distant and indistinct costae, 2 or 3 on the flanks and 3 in the sulcus.

Pedicle valve moderately convex in lateral profile; broadly and gently convex in anterior profile; umbonal and median regions inflated; sulcus originating at the middle; sulcus moderately wide and with its floor gently convex; sulcus bounded by the two strongest costae on the valve; flanks swollen. Tongue moderately long and rounded. Beak low.

Brachial valve with moderately convex lateral profile and strongly arched anterior profile with steep lateral slopes. Umbonal and median regions swollen. Fold low and inconspicuous. Flanks swollen.

Measurements in mm.—Holotype, length 6.2, brachial length 5.6, width 6.0, hinge width 1.0, thickness 4.4.

Types.—Holotype: 117139a; figured paratype: 117139b.

Horizon and locality.—Murfreeshboro formation in Tennessee: On Stone River just west of U. S. Highway 70S, $1\frac{1}{2}$ miles northwest of Murfreeshboro, Murfreeshboro (15') Quadrangle.

Discussion.—This species is characterized by its smooth posterior half or three-quarters and the indistinct nature of the costae on its flanks and in the sulcus. The species is unlike *C. immatura* in having more costae and in having some of

them occupying the median sulcus. It is quite unlike *C. minuta*, another small species, in the uncertain character of the costae. No other species are comparable.

CAMERELLA OBESA Cooper, new species

Plate 116, D, figures 25-34

Shell of about medium size for the genus, slightly wider than long and with the greatest width anterior to the middle; outline subpentagonal; apical angle about 100° . Sides narrowly rounded; anterolateral margins short, sloping strongly toward the middle; valves unequally convex, the brachial valve having the greater convexity. Surface mostly smooth, but anterior extension of tongue marked by 2 costae, anterior end of fold marked by 3 short costae, and anterior surface of flanks by 2 costae.

Pedicle valve gently convex in lateral profile and broadly but slightly convex in anterior profile; umbonal and median regions gently inflated; sulcus short and shallow, defined by 2 short anterior folds; tongue bent at a right angle, long, serrate, and with a truncated front; beak short.

Brachial valve fairly strongly convex in lateral profile but strongly domed in anterior profile; median region and umbo swollen; fold short and inconspicuous; flanks swollen and with precipitous sides.

Measurements in mm.—Holotype, length 9.6, brachial length 9.1, width 10.7, hinge width 2.1, thickness 8.3.

Types.—Holotype: 117140a; unfigured paratype: 117140b.

Horizon and locality.—Rockland formation in New York: On Mill Creek, Turin, Port Leyden (15') Quadrangle.

Discussion.—This species is like a small *C. volborthi* in its noncostate posterior and its obese form, but it is a much smaller species having a wider and squarer tongue on the pedicle valve. It is larger and ornamented by stronger costae than *C. tumida* from Newfoundland. *Camerella obesa* is similar to *C. ventricosa* from the Crown Point formation but differs in having a more strongly geniculated tongue and less strong costae.

CAMERELLA OKLAHOMENSIS Cooper, new species

Plate 71, F, figures 27-35

Shell of about medium size for the genus, slightly wider than long; brachial valve deeper than the pedicle valve; apical angle approximately a right angle; widest at the middle; surface semicostate, 3 costae on the fold, 2 in the sulcus, and 4 to 5 on the flanks.

Pedicle valve moderately convex in lateral profile with a bulge just posterior to the middle; anterior profile gently convex; sulcus originating abruptly a short distance anterior to the middle; sulcus narrow, moderately deep; tongue short; median region swollen; flanks narrowly rounded and with steep slopes.

Brachial valve strongly convex in lateral profile, strongly domed in anterior profile. Median region and flanks swollen and tumid. Fold low, short, originating anterior to the middle. Lateral slopes precipitous.

Measurements in mm.—Holotype, length 9.2, brachial length 8.5, width 10.2, hinge width 2.6, thickness 7.5.

Type.—Holotype: 117993.

Horizon and locality.—Bromide formation (Pooleville member—50 feet below the top) in Oklahoma: 0.1 mile southeast of the Observation Point on the Scenic Drive to Falls Creek, about 1 mile southeast of U. S. Highway 77, Murray County.

Discussion.—This species is one of the partly costate species and is characterized by 2 costae in the sulcus and 3 on the fold. It is suggestive of *C. plicata* (Schuchert and Cooper) but is a wider form with a somewhat wider apical angle. It is more strongly costate than *C. obesa* and *C. ventricosa*.

CAMERELLA PARVA Billings

Camerella parva BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 219, 1865.

Types.—G.S.C.

Horizon and locality.—Table Head series (Logan's divisions N, P) in Newfoundland: 4 miles northeast of Portland Creek.

CAMERELLA PENNSYLVANICA Cooper, new species

Plate 118, E, figures 45-49

Shell of about medium size for the genus, subpentagonal in outline; length and width about equal; posterolateral margins straight, forming an angle of 96° ; sides rounded; maximum width at or near the middle; anterior margin truncated; anterolateral margins short, gently curved. Surface paucicostate, posterior third smooth, anterior two-thirds costate, 4 costae on the fold, 3 in the sulcus, and 2 to 3 costae on the flanks.

Pedicle valve less deep than the brachial one, moderately and fairly evenly convex; anterior profile moderately convex; umbonal and median regions inflated; sulcus originating at about the middle, shallow and wide; tongue short, rounded; flanks narrow, moderately swollen, and with steep slopes. Beak short and incurved.

Brachial valve moderately convex but considerable curvature in the anterior half; anterior profile forming a highly convex dome with precipitous sides. Beak narrow; umbo and median region somewhat swollen; fold low and following closely the curve of the lateral profile; flanks fairly strongly swollen.

Measurements in mm.—Holotype, length 10.8, brachial length 10.1, width 10.8, hinge width 1.6?, thickness 7.9.

Type.—Holotype: 117142.

Horizon and locality.—Top of cherty beds in upper Row Park formation in Pennsylvania: In the field east of the railroad cut and on the north side of the Cumberland Valley RR., about 2 miles southwest of Marion, Chambersburg (15') Quadrangle.

Discussion.—This species is a partially costate form with obvious similarities to *C. plicata* (Schuchert and Cooper) but the apical angle is greater, the fold is

less prominent, and the sulcus is shallower. This species is unlike any other described Marmor *Camerella*. It is larger than, and ornamented differently from, *C. ventricosa* of the Crown Point limestone. The fold and sulcus are wider and deeper in *C. pennsylvanica* than in the type specimen of *C. varians*.

CAMERELLA PERPLEXA Cooper, new species

Plate 115, A, figures 1-5; plate 115, B, figures 6-11

Shell of fairly large size for the genus, length and width about equal; outline subpentagonal; posterolateral extremities long and straight forming an angle of 92° ; sides narrowly rounded; anterolateral extremities short and oblique toward the middle; anterior truncate; anterior commissure broadly uniplicate; valves unequally convex, the brachial valve having the greater depth. Surface costate, in the anterior four-fifths; umbonal region of both valves smooth; costae strong, angular, 4 on the fold, 3 in the sulcus, and 4 on the flanks.

Pedicle valve gently convex in lateral profile; broadly and gently convex in anterior profile; umbo somewhat swollen; sulcus originating about 4 mm. anterior to the beak, shallow in the median region but becoming deep at the anterior margin. Tongue only moderately geniculated, moderately long, and truncated. Flanks narrowly rounded and swollen and with steep lateral slopes. Beak moderately long.

Brachial valve moderately convex in lateral profile but strongly and roundly domed in anterior profile. Umbo moderately convex; median region swollen; fold wide and fairly strongly elevated in its anterior third. Flanks swollen and with precipitous sides.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.8+ | 11.2 | 12.2 | 2.8 | 8.5 |
| Figured specimen | 12.8+ | 11.6 | 13.1 | 3.5 | 9.0 |

Type.—Holotype: 117143; figured specimen: 111123.

Horizon and locality.—Elway formation, in Tennessee: $\frac{1}{2}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Same formation in Virginia: East of Moccasin Creek on Virginia County Highway 679, $\frac{3}{4}$ mile south of Tumbes, Moll Creek (T.V.A. 196-SE) Quadrangle.

Discussion.—This species is characterized by its erect form, strongly defined costae, and the presence of 3 costae in the fold and 4 on the sulcus. It differs from *C. globularis* from the Whistle Creek formation in its less convex valves and more erect beak. It differs from *C. multiplicata*, also of the Elway formation, in the less numerous costae and more robust shell. Its form is somewhat like *C. quadriplicata*, but it is not so robust and the details of the ornamentation are different.

CAMERELLA PLICATA (Schuchert and Cooper)

Plate 114, A, figures 1-24

Rhynchocamara plicata SCHUCHERT and COOPER, Amer. Journ. Sci., vol. 22, p. 248, 1931;
Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 189, pl. 25, figs. 1, 2, 17, 18 (not 7), 1932.

Shell of about medium size for the genus, somewhat triangular in outline, generally wider than long or with length and width nearly equal; greatest width about two-thirds the length from the beak. Angle formed by posterolateral margins slightly less than a right angle; anterolateral extremities narrowly rounded; front subtruncate. Posterior third to two-thirds of shell smooth, front half marked by narrowly rounded costae with interspaces about equal to width of costae, 2 occupying the sulcus, 3 the fold, and 3 to 4 marking the flanks. An occasional extra costa appears in the sulcus and a corresponding one on the fold.

Pedicle valve gently convex and with the maximum convexity in the posterior third. Sulcus originating at about the middle, shallow and occupying about half the width. Tongue short, truncated. Flanks slightly convex, slopes fairly steep. Median and umbonal parts slightly inflated. Spondylium long and deep.

Brachial valve moderately convex in lateral profile, nearly semicircular in anterior profile; about twice as deep as the pedicle valve. Fold low, in some specimens scarcely distinguishable from the body of the shell. Flanks moderately convex and with steep slopes. Median part somewhat inflated. Cruralium short, shallow, and narrow.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|-----------------|-------|-----------|
| Hypotype (IIII47c)..... | 10.8 | 10.0 | 10.9 | 8.3 |
| " (IIII43a)..... | 10.6 | 10.0 | 10.7 | 7.9 |
| " (II7144)..... | 10.5 | 9.9 | 10.5 | 7.7 |
| " (IIII39g)..... | 9.5 | 9.0 | 10.4 | 7.2 |

Types.—Lectotype: Y.P.M. S2035; figured hypotypes: IIII39d,g, IIII47a-c; measured hypotypes: IIII43a, II7144.

Horizon and locality.—Ridley formation in Central Basin of Tennessee: At Nice's (Ward's) Mill, on Stone River, 8 miles (airline) northwest of Murfreesboro; at Murfreesboro; Stone River Bridge on Tennessee Highway 96, 1 mile west of Murfreesboro; east side of Marshall Knobs, 5 miles south of Murfreesboro; Rutherford County; vicinity of Nashville, Nashville (15') Quadrangle.

Wardell formation in Tennessee: In the *Hesperorthis* zone on U. S. Highway 25E, $\frac{1}{2}$ mile northeast of Indian Creek, Evans Ferry section, Howard Quarter (T.V.A. 162-NW) Quadrangle; 1.1 miles northeast of Lee Valley and at Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species is variable but in general consists of partially plicate forms having 2 costae in the sulcus and a length and width about equal. The species suggests the bicostate form of *R. edmundsoni* but generally is not completely costate as in that form. It is very suggestive of *C. pennsylvanica* but has fewer costae in the sulcus and has a more strongly convex brachial valve.

CAMERELLA POLITA Billings

Camerella polita BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, pp. 304, 305, fig. 297, 1865.

Rhynchocamara polita (Billings) ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 251, 1938.

Types.—G.S.C.

Horizon and locality.—Mystic conglomerate, in Quebec, Canada: In Range 6, Lot 20, Stanbridge Township.

CAMERELLA ? PRIMIGENIA (Bradley)

Plate 109, G, figures 32-38

Anastrophia primigenia BRADLEY, Contr. Walker Mus., vol. 2, No. 6, p. 228, pl. 23, figs. 9-12, 1930.

This species is a peculiar completely costate type of *Camerella* rather than an *Anastrophia*. Members of the latter genus usually have a well-marked fold and sulcus. But Bradley's species is characterized as having the fold and sulcus visible chiefly at the anterior commissure. A section of the interior of a brachial valve showed the characteristic cruralium of the Camerellidae and failed to show the peculiar alate plates that are diagnostic of *Anastrophia*. The species is therefore best placed in *Camerella* until its true affinities can be determined.

Types.—Figured hypotypes: IIII75a,b, IIII77.

Horizon and locality.—Kimmswick formation in Arkansas: About $2\frac{1}{2}$ miles above the mouth of Cave Creek, 7 to 8 miles northwest of Batesville, Batesville (30') Quadrangle.

CAMERELLA PULCHRA Cooper, new species

Plate 114, B, figures 25-34; plate 116, E, figures 35-39; plate 116, F, figures 40-46

Shell of about medium size for the genus, longer than wide and with an elongate triangular outline; posterolateral margins long, forming an angle of about 80° . Greatest width in the anterior third and with narrowly rounded sides; anterior truncated. Anterior commissure somewhat narrowly but not strongly uniplicate. Surface costate except for smooth umbones; 3 costae on fold, 2 (occasionally 3) costae in sulcus, and 3 on the flanks.

Pedicle valve gently but unevenly convex in lateral profile, the most convex part just posterior to the middle. Anterior profile fairly strongly convex; umbonal region swollen; sulcus originating on the anterior side of the umbo just posterior to the middle; sulcus shallow and narrow throughout its length; flanks narrowly convex and with steep sides.

Brachial valve having a greater depth than the pedicle one, moderately convex in lateral profile; strongly convex in anterior profile; umbonal and median regions swollen; fold conspicuous in the anterior half but not strongly elevated; fold narrow; flanks narrowly rounded and having steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.0 | 9.5 | 9.0 | 3.2 | 7.2 |
| Paratype (IIII46b)..... | 9.4 | 9.3 | 9.0 | 3.0 | 7.6 |
| " (IIII46c)..... | 10.0 | 9.5 | 9.3 | 3.2 | 7.5 |

Types.—Holotype: IIII46a; figured paratypes: 85340a, IIII46b,c, II8012; unfigured paratypes: 85340b, IIII46d,e.

Horizon and locality.—Ridley formation in Rutherford County, Tenn.: C. St. L. and N. RR., $3\frac{1}{2}$ miles northwest of Murfreesboro; Murfreesboro; Nice's (Ward's) Mill on Stone River, 8 miles (airline) northwest of Murfreesboro, $3\frac{1}{2}$ miles northwest of Murfreesboro.

Discussion.—This species is characterized by its seminude exterior, the posterior half being without ornamentation but the anterior half strongly costate, and the shell generally elongate. It is strongly suggestive of *C. edmundsoni* in its elongate form, but the latter species is nearly completely costate. Its elongate form distinguishes *C. pulchra* from any of the Elway Camerellas except *C. multiplicata*, but that species is more finely and numerously costate.

CAMERELLA QUADRIPLICATA (Willard)

Plate III, B, figures 16-26

Camarotoechia quadriplicata WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 291, pl. 2, fig. 14, 1928.

Shell of about medium size for the genus, subtriangular to subpentagonal in outline, length and width approximately equal; beak angle about 100° , defined by slightly concave posterolateral margins; anterolateral extremities narrowly rounded, situated in the anterior third, and forming the greatest shell width. Anterior margin slightly rounded. Surface costate, 2 to 4 costae in the sulcus, 3 to 5 on the fold, and 5 or 6 on the flanks. Costae and interspaces covered by a felt of small granules.

Pedicle valve moderately convex in lateral profile and slightly convex in anterior profile. Sulcus originating about 4 mm. anterior to the beak in front of a gently convex umbo. Sulcus, widening anteriorly to occupy very slightly more than half the width at the front margin. Tongue short and abruptly truncated anteriorly. Flanks flattened adjacent to the sulcus but narrowly rounded at the margins to form steep posterolateral slopes. Delthyrium narrow, beak not elongated. Spondylium deep.

Brachial valve moderately convex and with a well-rounded umbo in lateral profile; narrowly convex and deeper than the pedicle valve in anterior profile. Umbo slightly swollen; fold low and gently rounded in profile. Flanks moderately depressed below the fold, well rounded and with steep lateral slopes.

Interior with spondylium and cruralium as usual in the genus.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|-----------------|-------|-----------|
| Hypotype (111157c)..... | 11.2 ? | 10.8 | 13.0 | 8.0 |
| " (111157b)..... | 13.7 | 12.5 | 14.0 | 9.6 ? |
| " (111157a)..... | 14.2 | 13.3 | 15.4 | 9.5 |

Types.—Figured hypotypes: 111155b, 111156a, 111157a,c, 118011a; measured hypotype: 111157b.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 2.1 miles southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; Evans Ferry; $\frac{3}{8}$ mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Lincolnshire formation in Tennessee: Near Marble Bluff, 8 miles west-northwest of Loudon, Loudon (30') Quadrangle.

Discussion.—Some forms of this species very closely resemble *C. bicostata* but differ therefrom in the presence of the minute granules, more numerous costae on the flanks, and the fact that the costae extend farther posteriorly toward the beak than in *C. bicostata*, in which the posterior half of the shell is generally smooth.

Willard originally referred this shell to *Camarotoechia*, and the presence of the granules are suggestive of some of the species originally called *Camarotoechia* in the Ordovician. Granules are present in some species of *Rostricellula* but are rare or hitherto unnoticed on members of the genus *Camerella*. In fact *C. quadruplicata* is the only *Camerella* noticed in this book which has granules.

CAMERELLA TENNESSEENSIS Cooper, new species

Plate 115, D, figures 22-31

Shell small with length and width about equal; outline subtriangular; apical angle 100° ; sides rounded; anterior truncated; anterior commissure broadly and gently uniplicate. Posterior half smooth, anterior half costate, 5 costae in the sulcus, 6 on the fold, and 5 on the flanks.

Pedicle valve gently convex in lateral profile and with the maximum convexity in the median region; anterior profile gently convex in the median region but the sides dropping steeply and abruptly; umbonal and median regions swollen; sulcus originating slightly anterior to the middle, wide and shallow. Tongue short and broadly rounded. Flanks narrowly rounded. Beak short, lying anterior to the brachial umbo.

Brachial valve moderately convex in the median region but with strongly curved umbo and anterior; strongly convex in anterior view and with precipitous sides. Median and umbonal regions swollen; fold slightly elevated; flanks narrowly rounded.

Measurements in mm.—Holotype, length 7.6, brachial length 7.9, width 7.9, hinge width 2.8, thickness 6.1.

Type.—Holotype: 111160.

Horizon and locality.—Middle part of Arline formation in Tennessee: On north side of wagon road in cedar glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is unlike any other *Camerella* known from the Appalachian region. It is characterized by the strongly arched umbonal region of the brachial valve so that the length of that shell is actually greater than that of the pedicle valve. In this respect the species resembles certain Canadian, Mystic, and Pogonip forms such as *C. breviplicata* Billings, *C. arkansasensis* (Ulrich and Cooper) and *C. sublaevis* (Ulrich and Cooper). It differs from all these in its possession of a broad fold having 6 costae, with 4 on the flanks.

CAMERELLA TRIANGULATA Cooper, new species

Plate 110, F, figures 22-35

Shell of about medium size for the genus, greatest width in the anterior portion; outline subtriangular; apical angle about 80° ; length and width about equal; valves subequal in depth. Surface smooth except for strong costae in anterior third; 2 costae in the sulcus, 3 on the fold, and 1 on the flanks.

Pedicle valve moderately convex in lateral profile and with the maximum convexity slightly posterior to the middle; anterior profile broadly and gently convex; umbo and median region swollen; sulcus originating at about the middle; sulcus wide and shallow. Tongue long, truncated on the front.

Brachial valve unevenly convex in lateral profile, with the maximum convexity near the middle. Anterior profile strongly convex with steep sides. Umbo narrowly swollen; median region inflated; fold narrow, moderately elevated at front; flanks narrowly rounded, terminating in a narrowly rounded lobe.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.5 | 8.0 | 8.2 | 1.8 | 6.3 |
| Paratype | 8.3 | 7.9 | 7.8 | 1.1 | 5.0 |

Types.—Holotype: 111162; figured paratype: 117145.

Horizon and locality.—Lenoir formation (shaly beds above *Valcourea* zone) in Tennessee: *Billingsaria* zone, $\frac{3}{4}$ and 1 mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; Knoxville; in front of church in center of Mosheim, Mosheim (T.V.A. 181-NW) Quadrangle; quarry on west side U. S. Highway 11, $1\frac{1}{2}$ miles southwest of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle.

Discussion.—This species is characterized by its elongate-triangular outline and the few strong but short costae located at the front margin. It suggests *C. varians* of the Mingan and Crown Point formations but differs from that species in having a less convex brachial valve and much stronger costae at the front margin. No other Appalachian species is like this one.

CAMERELLA TUMIDA Cooper, new species

Plate III, D, figures 36-40

Shell small for the genus, globular in outline and profile; length, width and thickness nearly equal; apical angle between 90° and 100° ; sides rounded; front margin truncated; surface finely costate in the anterior half but smooth on the posterior half; 4 costae on the fold, 3 in the sulcus, and about 4 on the anterior side of the flanks.

Pedicle valve with almost same depth as the brachial valve, moderately convex in lateral profile with a moderate bulge just posterior to the middle; umbo and median region inflated; sulcus originating at about the middle, shallow; tongue narrow, long and narrowly rounded, bent at right angles in a broad curve. Flanks narrowly rounded and with steep slopes. Beak strongly incurved.

Brachial valve nearly flat in the median region in lateral profile but with the front truncated and the umbo inflated; anterior profile forming a narrowly curved dome with a flattened top but with precipitous sides. Fold confined to the anterior half where it is moderately elevated. Flanks narrowly rounded.

Measurements in mm.—Holotype, length 7.1, brachial length 6.4, width 7.0, hinge width 2.0?, thickness 6.1.

Type.—Holotype: 117146.

Horizon and locality.—Table Head series (middle to lower) in Newfoundland: On Lower Head, 4 miles north of Cow Head.

Discussion.—This species is a small, compact form having most of the shell smooth. It is truncated at the front end and has a long, strongly geniculated tongue. It is somewhat like *C. obesa* but is more finely costate. It is also suggestive of *Camerella ventricosa*, but that species is larger and the tongue is not so strongly geniculated and the costae are stronger.

CAMERELLA UMBONATA Cooper, new species

Plate 108, G, figures 33-39

Shell of about medium size for the genus, length and width about equal; sub-circular in outline; sides somewhat rounded and front nearly straight; apical angle nearly 120° . Brachial valve considerably deeper than the pedicle one. Posterior half smooth, anterior half costate, 4 costae on the fold, 3 in the sulcus, and 2 on the flanks.

Pedicle valve shallow, nearly flat in lateral profile; anterior profile nearly flat; umbo gently inflated; sulcus originating at the middle, broad and shallow; tongue long and broadly truncated; flanks narrow and flattened but with their antero-lateral edges deflected away from the commissure; beak low and broad, slightly depressed and not protruding to the level of the umbo.

Brachial valve moderately convex but depressed anteriorly and with the umbo strongly swollen; anterior profile narrowly domed and with precipitous sides. Umbo and median region strongly inflated; fold prominent only in the anterior third where it is somewhat rounded in profile; flanks narrowly rounded.

Measurements in mm.—Holotype, length 8.1, brachial length 8.0, width 8.7, hinge width 2.6, thickness 6.4.

Type.—Holotype: 117147.

Horizon and locality.—Yellow limestone on 25-foot sandstone at base of Eureka group in Nevada: $3\frac{1}{2}$ miles N. 17° E. of Martin Ranch, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is somewhat like *C. tennesseensis* in having a strongly swollen brachial valve. It has 3 costae in the sulcus which is unusually wide. The species has the form of *Perimecocoelia* or *Parastrophina*, but the cruralium as seen when the shell is wet seems to be short and small like that of *Camerella*. This species is most like *C. virginensis* but differs in having a more tumid brachial valve, a more prominent fold, and a deeper sulcus.

CAMERELLA UNICOSTATA Cooper, new species

Plate 113, B, figures 6-9

Shell small, suboval in outline with the length slightly greater than the width. Greatest width at about the middle. Beak angle about 100° formed by slightly convex posterolateral margins. Lateral and anterior margins fairly strongly convex. Posterior half smooth, anterior half costate with a single costa occupying the sulcus, 2 costae on the fold, and 2 and an incipient third marking the flanks.

Pedicle valve with lateral profile gently convex; broadly convex in anterior profile. Posterior half gently convex; sulcus originating about 4 mm. anterior to the beak, abrupt, shallow, occupying less than half the width at the front margin. Costa bounding sulcus elevated above the others, narrowly rounded. Flanks narrowly rounded with steep lateral slopes.

Brachial valve more strongly convex than the pedicle one in lateral profile; strongly arched in anterior profile. Fold low and narrow, defined only at the front where it makes a small anteriorly projecting lobe. Flanks narrowly rounded with steep lateral slopes.

Measurements in mm.—Holotype, length 5.4, brachial length 4.9, width 5.0, thickness 4.0.

Type.—Holotype: 111161.

Horizon and locality.—Ward Cove formation in Tennessee: 2 miles south of Hall Crossroad, south of Hickey place, Fountain City (T.V.A. 146-SW) Quadrangle.

Discussion.—This species is of about the size and shape of *C. minuta* but differs in the possession of a single costa in the sulcus, a more oval outline, and less costate flanks.

CAMERELLA VARIANS Billings

Plate 110, B, figures 6, 7; plate 110, D, figures 12-15; plate 110, E, figures 16-21;
plate 118, F, figures 50-54

Camarella varians BILLINGS, Canadian Nat. Geol., vol. 4, p. 445, fig. 24, 1859; Geol. Canada, p. 127, fig. 52, 1863.—RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, pp. 250-253, pl. 36, figs. 25, 26, 1911.

(?) *Rhynchocamara varians* (Billings) TWENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 53, pl. 7, figs. 19-21, 1938.

The type lot of this species consists of two specimens: a fairly large one and a smaller one. The former has the length and width about equal; apical angle about 90° and the valves subequal in depth, the brachial valve somewhat deeper than the pedicle one. The sulcus is moderately wide but with a short tongue. The sulcus originates at about the middle and is occupied by 3 moderately strong costae that do not extend posteriorly as far as the place of origin of the sulcus. One or two short and faint costae occupy the flanks. The brachial valve has a low fold originating anterior to the middle and marked by 4 short costae. The flanks are marked by 1 or 2 indistinct costae. The brachial valve is moderately swollen and moderately convex in lateral profile. This specimen (G.S.C. 1038) is selected as the type of the species.

The second specimen is smaller and more elongate and has only 2 costae in the sulcus and 3 on the fold. It is probably a young form of the species, but not enough specimens of *C. varians* have ever been collected to make possible a study of its variation.

Types.—Lectotype: G.S.C. 1038; figured paratype: G.S.C. 1038a; figured hypotype: 111163; Y.P.M. 15284.

Horizon and locality.—Lower half of the Mingan formation in the Mingan Islands: St. Lawrence River on Parroquet, Eskimo, Bald, Mingan, and Niaspisca Islands and on Clearwater Point. Twenhofel and Whiting's specimen is from Eskimo Island. Twenhofel states that the species is common only on Mingan Island. It is not possible to tell from the description whether or not more than one species is included in the collections.

Crown Point formation in New York: On Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—*Camerella varians* has been fairly widely identified in rocks hitherto classified as Chazyan. The references to this species in the Table Head series of Newfoundland are probably wrong. The species is said to come from East Tennessee, but several specimens from that area so referred are here assigned to the new species *C. triangulata*. Specimens from the Crown Point limestone near Chazy identified by Dr. P. E. Raymond are also referred to a new species (*C. ventricosa*). The Mingan specimens and a few from the New York Chazy rocks are believed to belong to *C. varians*. See the above-mentioned species for comparisons.

CAMERELLA VENTRICOSA Cooper, new species

Plate 110, G, figures 36-49

Camarella varians RAYMOND, (not Billings), Ann. Carnegie Mus., vol. 7, p. 250, pl. 36, figs. 19-23 (not 24-28), 33-36 (doubtful), 1911.

Shell variable, generally somewhat broadly triangular to subpentagonal in outline; length equal to, greater than, or less than the width; apical angle varying from 75° to about 100° ; paucicostate, the posterior half generally smooth but the

anterior half costate; fold generally with 3 costae, sulcus with 2, and flanks with 1 or 2 depending on age.

Pedicle valve slightly less deep than the brachial one, moderately convex in lateral profile and with the maximum convexity slightly posterior to the middle; anterior profile broadly and gently convex; umbonal and median regions swollen, the maximum swelling just posterior to the sulcus; sulcus originating at the middle, wide and shallow; tongue long, its angle of geniculation not quite reaching a right angle; flanks narrowly rounded; beak fairly long and strongly incurved.

Brachial valve fairly strongly convex in lateral profile; anterior profile strongly domed and with precipitous sides. Umbo and median areas strongly swollen; fold originating at the middle, partaking of the general profile and only moderately elevated at the front. Flanks narrow and swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.8 | 8.7 | 10.1 | 3.1 | 8.0 |
| Paratype (IIII7ob)..... | 8.2 | 7.4 | 9.0 | 2.1 | 6.0 |
| “ (IIII7oc)..... | 9.5 | 8.7 | 8.7 | ? | 6.7 |
| “ (IIII7od)..... | 8.8 | 7.8 | 7.7 | 2.8 | 6.9 |

Types.—Holotype: IIII70a; figured paratype: IIII70d; unfigured paratypes: IIII70b,c.

Horizon and locality.—Crown Point formation (loose but from Brainerd and Seely's section 2, zone 3 of Division B) on Plattsburg (15') Quadrangle, New York: At Chazy; at the normal school ½ mile north of Plattsburg; Valcour Island.

Discussion.—This species is characterized by its compact form, the strongly geniculated pedicle tongue, the anteriorly costate and posteriorly nude exterior, and strong convexity. The species suggests *C. obesa* from the Trenton (Rockland) limestone, but the tongue is less geniculated and the costae extend farther posteriorly on the valves. It is also similar to *C. oklahomensis*, but it is larger and more convex although less strongly costate. *Camerella ventricosa* is a larger and more strongly costate species than *C. tumida* from Newfoundland.

CAMERELLA VOLBORTHI Billings

Plate 110, C, figures 8-11; plate 116, A, figures 1-5

Camarella volborthi BILLINGS, Canadian Nat. Geol., vol. 4, p. 301, 1859; Geol. Canada, p. 143, fig. 77, 1863.—HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 220, pl. 62, figs. 13-18 (not 11 and 12), pl. 84, fig. 42, 1894.—MILLER, North Amer. Geol. Paleont., p. 338, fig. 546, 1889.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, pl. 25, figs. 5, 20-22, 28-30, 1932.

This is one of the largest species of the genus now known. It may be recognized by this fact and by its almost completely smooth exterior. Costae are confined to the margins of the valves and are generally not strongly developed.

Types.—Lectotype: G.S.C. 1148a; paratype: G.S.C. 1148b; figured hypotype: 117148a; hypotype: G.S.C. not numbered.

Horizon and locality.—Cloche Island member of the Rockland formation in Ontario, Canada: South of Helen Lake, La Cloche Island, Manitoulin District. Rockland formation in Ontario, Canada: At Paquette Rapids.

CAMERELLA sp. 1

Plate 106, A, figures 1-5

Shell large for the genus, wider than long, subtriangular to subpentagonal in outline; variable; paucicostate with the fold having 3 costae and the sulcus 2 or 3; flanks with 2 to 4 costae; posterior half smooth.

Pedicle valve with gentle convexity to the lateral profile and slight convexity to the anterior profile. Umbonal region flatly convex, sulcus originating at the middle, deep and moderately wide; flanks flattened.

Brachial valve moderately convex in lateral profile; strongly convex in lateral profile; umbonal and median regions moderately swollen; fold originating at the middle, moderately elevated, somewhat narrow. Flanks moderately swollen and with steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------|--------|-----------------|-------|-------------|-----------|
| 117149d | 11.5+ | 10.9 | 12.1 | 3.5 | 8.1 |
| 117149b | 12.9+ | 12.2 | 16.9 | 3.7 | 8.7 |

Figured specimen.—117149d; measured specimen: 117149b.

Horizon and locality.—Low in the Benbolt formation in Tennessee: 0.1 to 0.2 mile north of the road, 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species suggests bicostate examples of *C. quadricostata* (Willard) from the Hogskin member of the Lincolnshire formation. It appears to be wider and to have more narrowly rounded lateral margins than the Hogskin species.

CAMERELLA sp. 2

Plate 112, F, figures 30-33

Three poorly preserved specimens, probably immature individuals. Small, paucicostate and narrowly lenticular in both profiles. There are 2 costae in the sulcus, 3 on the fold, and 3 on the flanks. Fold and sulcus originating at the middle, the former narrow and short, the latter shallow.

Measurements in mm.—117150a, length 7.8, brachial length 6.9, width 8.3, thickness 4.3.

Figured specimens.—117150a,b.

Horizon and locality.—Blackford formation (basal conglomerate zone) in Virginia: Just north of the junction of Virginia Highways 100 and 42, Staffordsville, Giles County.

CAMERELLA sp. 3

Plate 117, C, figures 13-18

Small, probably immature because of the slender profile; subtriangular in outline; paucicostate, the posterior two-thirds smooth, the anterior third costate

with 2 costae in the sulcus, 3 on the fold, and 1 on the flanks. Pedicle valve flatly convex in both profiles; sulcus originating two-thirds the length from the beak, broad and shallow; brachial valve deeper than the pedicle one and probably more convex; fold weathered away but apparently fairly wide and low as indicated by the pedicle tongue.

Figured specimen.—117151.

Horizon and locality.—Yellow beds above the 25-foot sandstone in Nevada: On the saddle just north of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

CAMERELLA sp. 4

Plate 121, E, figure 14

A single brachial valve indicates a species of *Camerella* different from others described herein. The specimen is 6.2 mm. long and 6.6 mm. wide. It is moderately convex in both profiles. The fold is low and margined by 2 costae that extend to about the middle. Between these costae the fold is gently depressed. The flanks are marked by 2 costae. The obscure costae appear in the depression bounded by the costae of the fold.

Figured specimen.—123294.

Horizon and locality.—Whitesburg formation in Tennessee: 1½ miles west of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Genus IDIOSTROPHIA Ulrich and Cooper, 1936

Idiostrophia ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 631, 1936; Geol. Soc. Amer. Special Pap. 13, p. 249, 1938.

This genus is most readily recognized by its triangular form. It is not common in any of its known occurrences. Previous to the present writing it was known only from boulders of the Mystic conglomerate which correspond in age to part of the Table Head series of Newfoundland. Several new species are added here which extend the geographic range to Nevada and Newfoundland.

The triangular form is not the only peculiar external character of the genus. It has a peculiar type of folding which may be characterized as broadly uniplicate. In *Camerella* a well-marked fold is generally present, and the flanks bounding fold and sulcus are fairly wide and prominent. In *Idiostrophia* the flanks bounding the sulcus are narrow folds, generally with an angular ridge facing outward and connecting with the beak. At its anterior extremity this fold generally terminates in a narrow lobe. The lateral lobes correspond to the flanks of the camerellid which bound the sulcus. Thus the broad and often somewhat swollen area between the lateral folds corresponds to the sulcus of the camerellid.

In the brachial valve the steeply sloping side is usually more or less deeply concave and forms a broad fold facing outward. At the anterior end of the fold a projection of considerable size, such as that in *I. nuda*, extends toward the pedicle valve and unites with it at the anterior point where the pedicle lateral plication dies out and the pedicle tongue is given off. At this point the pedicle valve is very shallow. The space between the brachial lateral ridges is thus the

brachial fold. The uniplication of these shells is thus obscure but definite nevertheless.

IDIOSTROPHIA COSTATA Ulrich and Cooper

Plate 109, B, figures 9-13

Idiostrophia costata ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 250, pl. 56C, figs. 4-6, 9-11, 1938.

Type.—Holotype: 92886.

Horizon and locality.—Boulder in Mystic Conglomerate in Quebec, Canada: Range 6, Lot 20, Stanbridge Township.

IDIOSTROPHIA NUDA Cooper, new species

Plate 109, E, figures 21-29

Shell of about medium size for the genus, length and width nearly equal, outline triangular; sides obliquely straight; anterior margin broadly rounded; valves unequally convex, the brachial valve having the greater depth; anterior commissure broadly uniplicate; surface of posterior four-fifths smooth; anterior margin marked by about 12 costae.

Pedicle valve moderately convex in lateral profile; broadly convex in anterior profile; umbonal region swollen; median region inflated but not so strongly inflated as the umbo; lateral region with a long, shallow depression marking a deflected area which defines a ridge extending from beak to slightly anterior to middle; side grooved between ridge and lateral commissure. Tongue wide.

Brachial valve unevenly convex in lateral profile with the umbonal region swollen and extending to the level of the beak of the pedicle valve; anterior commissure narrowly convex; median region swollen; sides precipitous, with a groove parallel to the lateral commissure; anterior forming a broad fold occupying the entire width; anterolateral extremities produced into a short flange that fits into a slot at the posterior of the tongue of the pedicle valve.

Interior unknown.

Measurements in mm.—Holotype, pedical length 10.4, brachial length 10.3, midwidth 9.1, anterior width 10.8, thickness 7.8.

Type.—Holotype: 117170.

Horizon and locality.—Pogonip group (mottled zone 700 feet below the Eureka quartzite) in Nevada: At the base of the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

Discussion.—This species is characterized by its fairly strongly inflated valves and the lack of ornamentation on the posterior four-fifths. The costellae along the front margin are also fairly delicate. The species is thus unlike any of those described herein.

IDIOSTROPHIA PAUCICOSTATA Cooper, new species

Plate 109, D, figures 18-20

Shell of about medium size for the genus, triangular in outline; sides nearly straight forming an angle of about 65°; anterior margin broadly rounded. Valves

of subequal depth, the brachial valve being slightly the deeper; anterior commissure very broadly uniplicate. Surface mostly smooth except for the anterior margin which is marked by 6 short costae.

Pedicle valve evenly and moderately convex in lateral profile; broadly and gently inflated; sides with a moderately deep groove marking off a marginal plica extending from the beak about four-fifths the distance to the margin.

Brachial valve moderately convex in lateral profile; anterior profile moderately convex; umbonal and median regions fairly strongly swollen; sides precipitous.

Measurements in mm.—Holotype, length 10.2, brachial length 10.0, midwidth 8.2, hinge width 1.5, anterior width 9.5, thickness 5.7.

Type.—Holotype: 117171.

Horizon and locality.—Pogonip group (sponge beds=*Anomalorthis* zone), in Nevada: In Ikes Canyon, $\frac{3}{4}$ mile above the mouth, east side of the Toquima Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species may be identified by its generally compressed form and the presence of a few strong costae confined to the anterior margin. The species is quite unlike *I. costata* Ulrich and Cooper which is more robust and which has the costae extending at least to the middle. It also differs from *I. paucicostata* which is more broadly triangular and in which the costae are stronger and occupy the anterior third.

IDIOSTROPHIA PERFECTA Ulrich and Cooper

Plate 109, A, figures 1-8

Idiostrophia perfecta ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 631, 1936; Geol. Soc. Amer. Special Pap. 13, p. 249, pl. 56F, figs. 15-17, 19-21, text figs. 12, 13, 1938.

Types.—Holotype: 92885a; paratypes: 92885b-d; figured hypotype: 117173.

Horizon and locality.—Mystic Conglomerate, in Quebec, Canada: Range 6, Lot 20, Stanbridge Township.

Table Head series (middle to upper half) in Newfoundland: $2\frac{1}{2}$ to 3 miles south of Belle Burns.

IDIOSTROPHIA PLICATA Cooper, new species

Plate 109, C, figures 14-17

Shell small for the genus, triangular in outline; length and width nearly equal; sides straight, forming an apical angle of about 70°. Anterior margin broadly rounded. Anterior commissure broadly uniplicate (?). Surface of posterior half smooth, anterior half marked by 4 strong, low, rounded costae.

Pedicle valve moderately convex in lateral profile, broadly convex in anterior profile. Umbonal marginal plica narrow ending anteriorly in a narrowly rounded projection. Lateral area narrowly grooved and concave. Beak small, incurved slightly.

Brachial valve somewhat more convex and somewhat deeper than the pedicle valve in lateral profile; anterior profile broadly and gently convex. Umbo narrowly swollen; median region gently inflated. Lateral area broadly concave.

Measurements in mm.—Holotype, length 9.4, brachial length 9.5, midwidth 6.6, anterior width 9.8, thickness 6.2.

Type.—Holotype: 117172.

Horizon and locality.—Table Head series in Newfoundland: At Table Point.

Discussion.—This species is broadly triangular and is marked along the anterior third by a few strong costae. The valves are also subequal in depth and both are moderately compressed. The species is unlike *I. costata* in outline and ornamentation; it is different from *I. paucicostata* in having the costae extend nearly to the middle.

IDIOSTROPHIA sp. 1

Plate 113, A, figures 1-5

Shell small, elongate triangular; posterolateral margins nearly straight, forming an apical angle of 55° ; greatest width at the front. Valves moderately convex in lateral profile; brachial valve slightly deeper than the pedicle valve. Surface smooth except at the anterior margin which is costate; 5 costae mark the pedicle valve and 4 the brachial valve. Median costa on pedicle valve opposing a median sulcus on brachial valve, both narrow. Brachial valve marked by a faint depressed line from beak to median depression. Both valves with median septa, that of the brachial valve being the longer.

Measurements in mm.—66308a, length 5.5, brachial length 5.3, width 4.4, thickness 2.9.

Figured specimens.—66308a,b.

Horizon and locality.—Boulder in Mystic conglomerate in Quebec, Canada: In Range 6, Lot 20, Stanbridge Township.

Discussion.—These specimens are the smallest ones of *Idiostrophia* known, but they may represent the young of some species. Immature characters may be seen in the fact that the odd number of costae is on the pedicle valve while the space between the median 2 on the pedicle valve forms an indistinct sulcus. No species is available for comparison.

Genus NEOSTROPHIA Ulrich and Cooper, 1936

Neostrophia ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 631, 1936; Geol. Soc. Amer. Special Pap. 13, p. 252, 1938.

NEOSTROPHIA ? GREGARIA Cooper, new species

Plate 120, A, figures 1-6

Shell small, subpentagonal to subcircular in outline, length and width about equal. Beak obtuse; greatest width generally at about the middle; sides rounded. Surface smooth.

Pedicle valve gently convex and with the greatest convexity in the umbonal region. Umbo somewhat narrowly swollen; sulcus originating at about the middle or slightly posterior to it, widening rapidly to occupy more than half the width, shallow and ending in a short, narrowly rounded tongue. Ridges bound-

ing sulcus prominent and subangular. Flanks concave to slightly convex and with steep slopes to the margins.

Brachial valve equal in depth to or slightly deeper than the pedicle valve, gently convex in lateral profile and with the greatest curvature at the umbo; moderately convex in anterior profile. Fold originating at the middle, somewhat narrowly rounded, moderately elevated. Flanks strongly rounded and with steep slopes to the margins.

Interior: Pedicle valve provided with an elongate spondylium supported by a septum that extends from the beak for fully a third the length. Cruralium of brachial valve short, supported by a septum extending from the beak nearly to the middle of the valve.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 6.2 | 5.9 | 6.5 | 4.3 |
| Paratype (111310a) | 6.5 | 6.4 | 7.4 | 3.3 |
| " (111310c) | 5.6 | 5.4 | 6.0 | 3.1 |

Types.—Holotype: 111310b; figured paratype: 111310a; unfigured paratypes: 111310c-f.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—These interesting little shells have been tentatively placed in the genus *Neostrophia* because of their camarelloid interiors and the strong rounded fold of the brachial valve. They differ from known *Neostrophia* in their small size and lack of anterior plication other than the median fold.

NEOSTROPHIA SUBCOSTATA Ulrich and Cooper

Plate 120, B, figures 7-16

Neostrophia costata ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 631, 1936; Geol. Soc. Amer. Special Pap. 13, p. 252, pl. 56G, figs. 18, 22-31, 35, text fig. 14, 1938.

Types.—Holotype: 66309a; paratypes: 66309b-f.

Horizon and locality.—Boulder in the Mystic conglomerate in Quebec, Canada: Range 6, Lot 20, Stanbridge Township, near Mystic.

NEOSTROPHIA ? sp. 1

Plate 120, C, figs. 17, 18

Shell small, pentagonal in outline; greatest width anterior to the middle; valves subequally convex; surface smooth. Pedical valve with a shallow sulcus originating just posterior to the middle. Brachial valve with a rounded, low fold set off from the flanks by shallow, narrow grooves. Fold often with small median groove and sulcus with faint median costa. Both valves with a long median septum.

Measurements in mm.—Brachial valve, length 4.3, width 3.8.

Figured specimens.—117176a,b.

Horizon and locality.—Ward Cove ? formation in Virginia: On Jeff Gillespie's place in Thompson Valley, 14 miles southwest of Tazewell, Pounding Mill (15') Quadrangle.

Discussion.—The position of this little species is uncertain. The specimens may represent the young of some *Camerella*, but they seem more like adults. The median fold is better developed than is usual in the young of *Camerella*. The specimens suggest *N. ? gregaria* but have a more pronounced fold and a more elongate outline.

LIRICAMERA Cooper, new genus

(Latin, *lira*, ridge between 2 furrows; *camera*, chamber)

Biconvex, subcircular in outline, gently uniplicate; surface completely costellate. Pedicle valve with moderately wide interarea. Pedicle interior with long spondylium supported by a long median septum. Brachial interior with a shallow cruralium like that of *Camerella*.

Genotype.—*Liricamera nevadensis* Cooper, new species.

This genus is clearly an early elaboration of *Camerella* which still retains some primitive characters. The interior details are like those of *Camerella* and need not be elaborated. The genus differs from *Camerella* in the completely costellate exterior, most *Camerellas* being smooth in the posterior third, half, or quarter, and strongly costate in the anterior part. It differs also in the possession of a fairly wide and well-developed interarea on both valves. Furthermore, the gentle degree of folding of the anterior commissure is another distinction from *Camerella*.

The ornamentation actually suggests that of some species of *Idiostrophia* in the median groove on one valve. At present this genus is known only from the *Orthidiella* zone of the Pogonip formation which contains many other peculiar brachiopods. The genus is thus a lateral branch of *Camerella* retaining primitive features.

LIRICAMERA NEVADENSIS Cooper, new species

Plate 110, H, figures 50-57; plate 122, A, figures 1-8

Subcircular in outline, with all margins rounded; beaks inconspicuous; valves nearly equal in depth; anterior commissure gently uniplicate; surface costellate, costellae narrowly rounded, about 45 in number; brachial valve with a narrow median groove; pedicle valve with a corresponding median costella stronger than the surrounding ones, bifurcated at the front to receive a faint median costella.

Pedicle valve strongly convex in lateral profile, strongly arched in anterior profile; beak erect, incurved moderately; umbonal and median regions swollen; flanks swollen and with steep slopes. Median part of anterior third slightly depressed to form a faint sulcus. Spondylium deep and narrow; septum long. Interarea well developed.

Brachial valve slightly less convex than the pedicle valve in lateral profile; anterior profile strongly convex; entire valve swollen; lateral slopes steep; median region forming a faint fold. Midline marked by a narrow depression

wider than the other striae and bearing a faint costella. Cruralium shallow and wide; fulcral plates well developed; brachiophores short, crescentic in section; median septum long, elevated. Interarea moderately well developed.

Measurements in mm.—Holotype, length 11.7, brachial length 10.8, width 11.2, hinge width 4.9, thickness 8.3.

Types.—Holotype: 117174g; figured paratypes: 117174d-f,h, 117175b-d,h; unfigured paratypes: 117174a-c,i-l, 117175a,e,f.

Horizon and locality.—Pogonip group (*Orthidiella* zone) from the mottled zone 700 feet below the Eureka quartzite in Nevada: At the base of the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle.

Discussion.—No other species like this one is now known.

PERIMECOCOELIA Cooper, new genus

(Greek *peri*, around; *meco*, long; *koilos*, hollow)

Transversely and broadly elliptical in outline; biconvex but with the brachial valve having the greater depth; strongly uniplicate; paucicostate, the posterior half smooth and the anterior half or less costate.

Pedal valve with an elongate spondylium, narrowed anteriorly, and supported by a short median septum.

Brachial valve with long cruralium supported by a short median septum not continued anteriorly; brachiophores short and stout; fulcral plates small, defining a small socket. Adductor field longitudinally elliptical, partially divided by the cruralium.

Genotype.—*Perimecocoelia semicostata* Cooper, new species.

Discussion.—This genus externally is very suggestive of *Parastrophina* because of its transversely elliptical outline, strongly swollen brachial valve, and paucicostate ornamentation. The transverse outline separates the genus from most of the camerellids which are usually longitudinally oval or somewhat triangular.

Inside the pedicle valve the spondylium is like that of *Camerella* and its allies in its elongate form and the narrower anterior. Many specimens of *Perimecocoelia* have the spondylium nearly divided into two chambers by processes growing inwardly from near the center of the structure. No specimens have been found in which the processes united, although in a few instances they have almost done so.

The interior of the brachial valve is most suggestive of that of *Parastrophina* with its long cruralium. However, it differs from that genus in not having the alate plates and in possessing a much shorter median septum. The cruralium of *Perimecocoelia* is quite unlike that of *Camerella* which is short and confined to the beak and supported by a long median septum.

In all the many specimens of the brachial valve available for study the brachiophores are short and stubby. Furthermore, they appear to lie under the fulcral plate which forms an S-bend from the inner wall of the valve to the posterior

edge of the brachioophore. This is similar to the structure of the brachial plates of *Camerella*. *Perimecocoelia* is thus a camerellid with elongate cruralium.

The adductor field of *Perimecocoelia*, at least in the present species, is somewhat thickened and is often surrounded by an elevated callus. The posterior scars are located beside the anterior end of the cruralium; the anterior scars, which are the larger, are located just anterior to the end of the cruralium and are separated by a low ridge extending anterior to the cruralium.

PERIMECOCOELIA ELLIPTICA Cooper, new species

Plate 111, C, figures 27-35

Shell small, broadly triangular in outline, with low, inconspicuous beaks. Brachial valve slightly deeper than the pedicle valve. Both profiles narrowly lenticular. Paucicostate, the posterior half smooth and the anterior half strongly costate; 2 costae in the sulcus, 3 on the fold, and 2 on the flanks; fold low, defined by the 3 strongest costae slightly elevated at the anterior third. Sulcus shallow and wide, originating in the anterior third.

Measurements in mm.—Holotype, length 7.0, brachial length 7.0, width 8.5, hinge width 1.7, thickness 4.7.

Type.—Holotype: IIII164.

Horizon and locality.—Arline formation in Tennessee: North side of old wagon road in cedar glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is similar to *P. semicostata* but is smaller, with only 2 costae in the sulcus and becoming costate at a less distance from the beak. The interior of the species is not known, but the elliptical outline, wide sulcus, and semicostate form all suggest reference to *Perimecocoelia* rather than *Camerella*.

PERIMECOCOELIA SEMICOSTATA Cooper, new species

Plate 108, E, figures 21-25; plate 114, C, figures 35-38; plate 117, E, figures 28-51;
plate 117, F, figures 52-59; plate 119, B, figures 6, 7

Parastrophia rotundiformis WILLARD (part), Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 290, 1928.

Shell transversely but broadly elliptical in outline; posterior margin broadly rounded; lateral margins strongly rounded; anterior margin somewhat truncated. Anterior commissure strongly uniplicate; posterior half smooth; anterior half costate with 3 (rarely 4) costae on the brachial fold and 1 to 3 obscure ones on the flanks; 2 costae (rarely 3) in the sulcus, and 2 to 4 poorly defined ones on the flanks.

Pedicle valve unevenly convex in lateral profile, with the most convexity in the posterior region and with a strongly geniculated tongue; anterior profile slightly convex; umbonal region gently swollen; sulcus originating slightly posterior to the middle, deepening and widening abruptly; sulcus bounded by 2 subangular costae that die out with the sulcus posteriorly; flanks nearly flat,

with moderately steep slopes. Spondylium long and slender, constricted more or less strongly near the middle. Tongue long, truncated but strongly serrate.

Brachial valve with much greater depth than the pedicle valve and with uneven lateral profile, the umbonal region swollen but the median and anterior regions only moderately convex; anterior profile strongly bowed. Umbonal region swollen and protruding somewhat posterior to the posterior margin. Median region swollen. Fold low, rounded in anterior profile, originating near the middle; flanks swollen, with precipitous slopes. Interior with long and deep cruralium, thickened adductor field, and no median septum.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (brachial valve)..... | ? | 9.6 | 12.4 | ? | ? |
| Paratype (pedicle valve 117159f)..... | 11.2 | ? | 14.2 | 3.2 | ? |
| " (" " 111338)..... | 11.0 | 10.5 | 12.8 | 3.9 | 7.4 |
| " (" " 111336b)..... | 9.5 | 9.0 | 10.7 | 3.2 | 4.7 |
| " (" " 111333c)..... | 9.4 | 9.4 | 10.4 | 3.2 | 5.5 |

Types.—Holotype: 117159b; figured paratypes: 117159a,c,d,f, 117161, 111328e, 111333b, 111334b, 111336b, 111338, 111347a, 118013b-f; unfigured paratypes: 111333a,c,d, 111334a,c,d, 111336a,c, 117159e, 118013a.

Horizon and locality.—Effna formation in Virginia: At McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; Tilson Mill, 16 miles northeast of Marion, Nebo (T.V.A. 223-NW) Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: 4 miles southwest of Bland, Bland County; 1.8 miles S. 4° W. of Bethel Church, 5.9 miles due east of Harrisonburg, Harrisonburg (15') Quadrangle.

Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Botetourt formation in Virginia: 1 mile northwest of Lexington, Lexington (15') Quadrangle.

Edinburg formation (*Cyrtototella* zone) in Virginia: In the ravine at the switch about $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Lower 3 feet of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Lower Benbolt formation in Virginia: On the south side of Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle.

Discussion.—The species is suggestive of *Parastrophina hemiplicata* of the New York Trenton but is less costate and less tumid than is usual in that species. It is distinguished from *P. triangulata* by its larger size and elliptical outline.

Willard proposed the name *Parastrophia rotundiformis* for *P. rotunda* Winchell and Schuchert from the Prosser of Minnesota and Iowa which was preoccupied by *Atrypa rotunda* Sowerby when that species was assigned to the genus *Parastrophia*. Willard referred his Virginia specimens to the Prosser species, but a number of important differences exist. The Virginia specimens belong to

the genus *Perimeocococelia* rather than *Parastrophina* and are referred to *P. semicostata*. The Minnesota species *Parastrophina rotundiformis* is a much larger one with more convex valves than the Virginia species. Furthermore, the Prosser form is more strongly costate and the costae extend at least to the middle of the valves.

PERIMECOCOELIA TRIANGULATA Cooper, new species

Plate 117, B, figures 3-12

Shell small for the genus, triangular in outline; greatest width anterior to the middle; anterolateral extremities narrowly rounded; sides slightly convex. Posterior two-thirds smooth, anterior third costate, 2 costae marking the sulcus, 3 the fold, and 1 strong costa and an obscure one marking the flanks.

Pedicle valve gently convex in the posterior half, nearly flat anteriorly; umbonal region gently swollen; sulcus originating anterior to the middle, moderately deep and forming a short, truncated tongue anteriorly; flanks narrow, slightly deflected in the direction of the pedicle valve toward the front.

Brachial valve 2 to 3 times as deep as the pedicle valve, moderately convex in lateral profile with strongly arched and swollen umbo that protrudes anterior to the pedicle beak. Fold originating near the middle, narrow, low; flanks depressed, strongly rounded and with steep slopes to the margins.

Measurements in mm.—Holotype, length 7.8, brachial length 7.9, width 8.2, thickness 6.4.

Types.—Holotype: III342a; unfigured paratypes: III342b-f.

Horizon and locality.—Effna formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species differs markedly from *P. semicostata* in outline and proportions although the costation is similar.

PLETOCAMARA Cooper, new genus

(Greek *plektos*, fold; *camara*, chamber)

Shells small to moderately large, rhynchonelloid in outline and profile. Pedicle valve shallower than the brachial valve and with a deep sulcus and long tongue. Beak suberect; delthyrium as in all camerellids. Brachial valve with prominent median fold. Valves completely costate; entire surface covered by closely crowded wavy, elevated, concentric lines. Pedicle interior with deep, narrow spondylium supported by a short median septum. Brachial interior with short brachiophores attached to the floor of the valve to form a narrow notothyrial cavity. Median septum absent or only a short ridge in front of the notothyrial cavity.

Genotype.—*Plectocamara costata* Cooper, new species.

Discussion.—At first glance the species of this genus suggest small rhynchonellids such as *Camarotoechia* or *Rhynchotrema*, but study of the delthyrial region, which has no deltidial plates and is like *Camerella*, will, along with the interiors, help to distinguish these peculiar little shells. Inside the pedicle valve the spondylium is long, narrow, and deep and is sessile at the posterior as is

common with camerelloid shells. The median septum is best defined at the front of the spondylium but is not extended for a great distance anterior to the anterior end of that structure.

The most important features are in the interior of the brachial valve. The brachiophores and their supports are like those of *Camerella*, but instead of meeting the median septum in the direction of the brachial valve they are attached to the floor to form a narrow notothyrial cavity rather than a short cruralium as in *Camerella*. In *Plectocamara* the median septum is reduced to a mere ridge extending anteriorly of the notothyrial cavity for a short distance and dividing the small adductor impressions.

PLECTOCAMARA ASEPTATA Cooper, new species

Plate 122, C, figures 22-26; plate 122, D, figures 27-29; plate 123, B, figures 7-11; plate 123, C, figures 12-16; plate 123, G, figures 32-54; plate 126, E, figures 25-29

Small subtriangular to subelliptical in outline, wider than long, widest slightly anterior to the middle. Beak obtuse, sides straight; anterolateral extremities narrowly rounded. Anterior margin straight. Surface costate, costae subangular, with the flanks marked by 7 or 8 and the fold by 3 or 4, with 2 or 3 costae in the sulcus.

Pedicle valve gently convex in lateral profile and broadly convex in anterior profile. Beak short, suberect. Umbo gently convex. Sulcus originating $1\frac{1}{2}$ to 2 mm. anterior to the beak, strongly depressed anteriorly to form a fairly sharply geniculated tongue. Flanks bounding sulcus flattened to slightly convex and with gentle slopes to the margin in the anterior region and steepening posteriorly.

Brachial valve moderately convex in lateral and anterior profiles; fold originating about 1 mm. anterior to the beak, moderately strongly elevated anteriorly. Flanks depressed below fold, gently rounded and with gentle slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 6.1 | 5.4 | 7.2 | 4.1 |
| Paratype (111361b) | 5.6 | 5.2 | 6.5 | 3.4 |
| " (111361c) | 5.2 | 4.8 | 6.1 | 3.9 |

Types.—Holotype: 111361a; figured paratypes: 111361b,c, 117180b, 117181, 117182a-d; unfigured paratypes: 111370a, 117182e; figured specimen: 117180a.

Horizon and locality.—Lower Benbolt formation in Virginia: $1\frac{1}{2}$ miles west of Rye Cove at the Brick Church, Clinchport (T.V.A. 188-NW) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; south side of Mount Hagan Church, Hilton (T.V.A. 197-NW) Quadrangle.

Benbolt formation in Tennessee: At Evans Ferry, U. S. Highway 25E, north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle.

From limestone with *Oligorhynchia* in Virginia: $\frac{1}{2}$ mile southeast of Richpatch, Eagle Rock (15') Quadrangle.

Ward Cove formation in Tennessee: 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle.

Sevier formation in Tennessee: $\frac{1}{4}$ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This species can be recognized by its fairly large size, obtuse and elevated beak, narrowly rounded anterolateral extremities and numerous costated flanks. It differs from *P. costata* in the latter character as well as in size and form.

PLECTOCAMARA COSTATA Cooper, new species

Plate 122, B, figures 9-21; plate 123, E, figures 22-26; plate 123, F, figures 27-31;
plate 138, F, figures 40-42

Shell small, subpentagonal in outline; posterolateral margins straight forming an angle of about 120° . Sides narrowly rounded; anterior margin subtruncated; anterior commissure strongly uniplicate; surface costate, fold marked by 3 costae, sulcus containing 2 costae, and flanks marked by 4 costae.

Pedicle valve slightly convex in lateral profile; broadly convex in anterior profile but depressed medianly; umbo smooth; sulcus originating about 1 mm. anterior to the beak, deepening rapidly and forming a moderately long, narrow tongue. Flanks depressed convex, with gentle slopes.

Brachial valve deeper than the pedicle one and moderately convex in lateral profile; strongly convex in anterior profile. Fold originating on the umbo, strongly elevated at the front and with steep sides. Flanks rounded and with steep slopes depressed below the fold. Interior with sessile cruralium.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 5.5 | 5.2 | 6.6 | 1.5 | 3.9 |
| Paratype (111368a) | 4.6 | 4.2 | 4.9 | 1.0 | 1.9 |

Types.—Holotype: 111360a; figured paratypes: 111356, 111368a,b, 117184, 117943a,b; figured specimen: 123457; unfigured paratype: 117184b.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 3 and $4\frac{1}{2}$ miles west-southwest of Thorn Hill; 0.4 mile east-northeast of Red Hill; $\frac{1}{2}$ mile north of Thorn Hill on U. S. Highway 25E; Avondale (T.V.A. 162-SW) Quadrangle; 1 mile southwest of Washburn, Dutch Valley, (T.V.A. 154-SE) Quadrangle; $\frac{1}{2}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; $\frac{1}{4}$ mile north of Rose Hill, Maynardville (T.V.A. 145-SE) Quadrangle; $\frac{1}{2}$ mile southwest of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle; Evans Ferry section, north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; 2 miles southwest and 1.7 miles northwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle.

Lincolnshire formation in Virginia: Quarry at Marcem, 2 miles west of Gate City, Gate City (T.V.A. 188-SE) Quadrangle.

Ward Cove formation in Tennessee: $\frac{3}{4}$ mile southeast of Mount Eager Church, Powder Springs (T.V.A. 154-SW) Quadrangle.

Discussion.—This species differs from *P. aseptata* in having less numerous and less closely spaced costae, in having a less narrow umbo and less erect beak, in having little tendency for development of extra costae on the fold and the sulcus, less costae on the flanks, and in having the fold originate nearer the middle. The two species are actually fairly similar, but no instances of 3 costae in the sulcus and 4 on the fold have been observed in *P. costata*.

Like *P. aseptata* this species is also a very variable one, but the variations are not as extreme as in the Benbolt species. Generally, *P. costata* does not attain as large a size as *P. aseptata*, and the sulcus is not usually so deep. Furthermore, the species is more conservative in its costation, the costae of the flanks remaining fairly constant.

PLECTOCAMARA ERECTA Cooper, new species

Plate 123, D, figures 17-21

Shell of usual size for the genus, length and width about equal; outline sub-pentagonal; posterolateral margins straight, lateral margins narrowly rounded; anterior margin truncated. Strongly uniplicate. Surface costate, with 3 costae on the fold, 2 in the sulcus, and 4 on the flanks.

Lateral profile slightly convex but with a local inflation at the umbo; anterior profile faintly convex. Sulcus originating 2 to $2\frac{1}{2}$ mm. anterior to the beak, deepening anteriorly and terminating in a narrow, short tongue. Sides of sulcus precipitous at the front. Costae bounding sulcus elevated and protuberant anteriorly; flanks flat and inclined fairly steeply.

Brachial valve moderately convex in lateral profile, broadly and moderately convex in anterior profile; brachial valve slightly deeper than the pedicle valve; umbonal region moderately inflated; fold originating on the umbo but not elevated strongly throughout its length. Fold rounded in lateral profile; flanks moderately swollen and with steep slopes, not strongly depressed below the level of the fold.

Measurements in mm.—Holotype, length 5.5, brachial length 5.1, width 5.9, hinge width 1.4, thickness 3.7.

Type.—Holotype: 117183.

Horizon and locality.—Wardell formation in Tennessee: Northeast side of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species is characterized by its erect form, the width and length being nearly equal, and by the sparse costation. It differs from *P. aseptata* in having less width, less costae, and a narrower fold and sulcus. *Plectocamara erecta* is also similar to *P. costata* in its costation, but it is not so wide, has a more swollen brachial valve, less elevated fold, and a narrower sulcus.

Plectocamara is a rare genus in the Wardell formation. Consequently, the foregoing species is based on a single good specimen and one other exfoliated one which shows some details of the interior.

PLECTOCAMARA MAGNA Cooper, new species

Plate 122, G, figures 38-51

Large for the genus, wider than long, with a transversely but broadly elliptical outline; nearly as thick as long. Sides oblique, straight, forming an apical angle of 125° . Sides narrowly rounded; anterior margin truncated. Strongly uniplicate. Surface costate, 3 costae on the fold, 2 in the sulcus, and 7 on the flanks.

Pedicle valve fairly strongly convex in lateral profile with the maximum convexity at about the middle. Anterior profile broadly and gently convex; sulcus originating about 1 mm. anterior to the beak, narrow, deepening and widening moderately anteriorly where it occupies about one-third the width at the front margin. Tongue long and narrow. Sulcus with precipitous sides defined by strong marginal subangular costae. Flanks moderately convex and with moderate slopes depressed below the costae forming the sulcus margin. Spondylium moderately large and deep.

Brachial valve having about the same convexity and depth as the pedicle valve in lateral profile; anterior profile with gently convex top but steeply sloping sides. Umbonal region moderately swollen. Fold originating on the umbo, narrow and strongly elevated anteriorly, with precipitous sides at the front. Flanks moderately swollen and depressed well below the fold. Brachial plates stout; muscle marks deep and prominent.

Measurements in mm.—Holotype, length 8.0, brachial length 7.3, width 9.5, hinge width 2.8, thickness 7.3.

Types.—Holotype: 117185a; figured paratype: 117185b; unfigured paratype: 117185c.

Horizon and locality.—Base of Shippensburg formation (Pinesburg member-*Echinospaerites* zone) in Maryland: On U. S. Highway 40, near Wilson on the west side of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Edinburg limestone (*Cyrtonotella* zone) in Virginia: Ravine at the switch $\frac{1}{8}$ mile east of Strasburg Junction; 0.2 mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Discussion.—This species is characterized by its large size and tumid valves. Except for *P. transversa* it is the largest species known. It differs from *P. aseptata*, which it most resembles, in having a narrower fold and sulcus, more costae on the flanks, and a less erect beak. *Plectocamara transversa* has a wider hinge, wider sulcus, and more costae on the flanks than *P. magna*.

PLECTOCAMARA ROTUNDA Cooper, new species

Plate 122, E, figures 30-34; plate 268, C, figures 7-11

Large for the genus, slightly wider than long; transversely and broadly elliptical to subcircular in outline. Sides broadly rounded; anterior margin truncated. Strongly uniplicate. Surface costate, 3 costae (rarely 4) on the fold, 2 (rarely 3) in the sulcus, and 5 to 7 on the flanks.

Pedicle valve gently convex in lateral profile; broadly and gently convex in anterior profile. Umbonal region gently convex; sulcus originating 2 mm. anterior to the beak, deepening rapidly and occupying about half the width at the front. Tongue long, bent at an angle slightly greater than a right angle. Sides of sulcus opposite place of geniculation of tongue precipitous and bounded by an extravagantly developed costa on each side. Flanks gently convex but with steep slopes.

Brachial valve somewhat deeper than the pedicle valve, slightly more convex in lateral profile; anterior profile narrowly convex and with steep lateral slopes. Umbonal and median region flattened. Fold originating at or near the middle, strongly elevated anteriorly and with precipitous sides. Flanks strongly rounded and with steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 5.7 | 5.5 | 6.6 | 1.9 | 4.4 |
| Paratype (117186b) | 6.2 | 5.7 | 6.7 | 2.1 | 5.8 |
| " (117186c) | 6.2 | 5.7 | 6.5 | 2.1 | 5.3 |
| " (117186d) | 6.0 | 5.4 | 7.1 | 2.2 | 4.8 |

Types.—Holotype: 117186a; figured paratype: 117186e; unfigured paratypes: 117186b-d.

Horizon and locality.—Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—This species is characterized by its rotund form and considerable thickness. It is suggestive of the Benbolt *P. aseptata* but differs in its greater thickness, flattened umbo of the brachial valve, and more extravagantly developed fold and sulcus. These features will also differentiate it from *P. costata*.

PLECTOCAMARA SULCATA Cooper, new species

Plate 123, A, figures 1-6

Shell small, wider than long, sides narrowly rounded; strongly uniplicate; costate, with 2 costae in the sulcus, 3 on the fold, and 4 on the flanks.

Pedicle valve nearly flat in lateral profile with the surface sloping anteriorly; anterior profile gently convex; sulcus originating about 1 mm. anterior to the beak, deepening abruptly, but narrow throughout. Sides of sulcus precipitous; costae bounding sulcus produced anteriorly and greatly elevated in a direction toward the pedicle valve; flanks flattened but with steep slopes.

Brachial valve gently convex in lateral profile; moderately convex in anterior profile. Fold originating slightly anterior to the middle, abruptly but not strongly elevated. Fold narrow and with closely crowded costae. Flanks moderately swollen, depressed anteriorly to emphasize the lateral margins of the fold.

Measurements in mm.—Holotype, length 4.2, brachial length 3.8, width 5.1, hinge width ?, thickness 3.3.

Type.—Holotype: 117187.

Horizon and locality.—Benbolt formation in Virginia: On the south side of

Mount Hagan School, southeast corner of the northeast subquad., Hilton (T.V.A. 197-NW) Quadrangle.

Discussion.—This species is most similar to small, strongly costate specimens of *P. aseptata* but differs in the greater depth of the sulcus and in the extravagant development of the anterior ends of the costae bounding the sulcus.

PLECTOCAMARA TRANSVERSA Cooper, new species

Plate 122, F, figures 35-37

Shell large for the genus, wide, with gently oblique posterolateral margins forming a broadly obtuse apical angle. Sulcus originating at the beak, deep and moderately wide, occupied by 2 costae. Flanks flattened to gently concave, depressed below the strong bounding costae of the sulcus, marked by 9 costae. Lateral profile gently convex. Spondylium short, deep, sessile at the posterior but elevated on a short median septum at the anterior.

Measurements in mm.—Holotype, length 8.7, width 12.4.

Type.—Holotype: 117188.

Horizon and locality.—Edinburg formation (lower part of *Nidulites* zone) in Virginia. On U. S. Highway 11, 100 yards south of Battlefield Crystal Caverns entrance, 1 mile north of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This is the largest of the known species of this genus. Besides its size it is characterized by its great width and numerous costae.

Subfamily STENOCAMARINAE Cooper, new subfamily

Camerellidae having long, discrete, subparallel dental plates in the pedicle valve.

STENOCAMARA Cooper, new genus

(Greek *steno*, narrow; *camara*, chamber)

Shell suggesting *Camerella* in outline and profile but not plicated except for fold and sulcus. Anterior commissure strongly uniplicate; hinge narrow; surface marked by concentric lines of growth only.

Pedicle valve more or less strongly sulcate; beak small, somewhat incurved; interarea small and narrow; interior with 2 long, subparallel dental plates defining a long, deep, and very narrow delthyrial chamber.

Brachial valve with incurved beak and strong median fold; interior characterized by a short V-shaped cruralium supported by a long and elevated median septum.

Genotype.—*Stenocamara perplexa* Cooper, new species.

Discussion.—This genus is characterized by having subparallel dental plates in the pedicle valve and a cruralium in the brachial valve. Externally the genus suggests the syntrophids because of its smooth exterior and strongly uniplicate anterior commissure. The structure of the brachial valve is most like *Xenelasma* Ulrich and Cooper which occurs in the Nittany formation and its equivalents in Virginia, Tennessee, and Texas. *Xenelasma* is characterized by having dental

plates in the pedicle valve and a cruralium in the brachial valve. Exteriorly this genus is smooth but has rotund moderately uniplicate shells. *Stenocamara* differs from *Xenelasma* in having exceptionally long dental plates and an exceedingly narrow delthyrial chamber, whereas these features in the Canadian genus are shorter and wide. In the brachial valve the two also differ. *Xenelasma* is characterized by an elongate and almost sessile cruralium; the same structure in *Stenocamara* is short and like that of *Camerella*. This genus thus combines features of the camerellids and of the syntrophids.

STENOCAMARA BICOSTATA Cooper, new species

Plate 115, G, figures 43-48

Shell small, slightly wider than long; greatest width slightly anterior to the middle; beak slightly greater than a right angle, posterolateral margins straight; lateral margins narrowly rounded; front truncated. Surface smooth in the posterior half and on the flanks. Sulcus with 2 costae and the fold with 3.

Pedicle valve slightly convex with the greatest convexity at the umbo; sulcus originating at about the middle, wide and shallow, occupying more than half the shell width; tongue short. Midregion slightly swollen. Flanks slightly concave and with very gentle slopes to the margins. Interior with long, slightly diverging dental plates.

Brachial valve gently convex in the anterior part but strongly convex in the umbonal region; strongly convex in anterior profile; swollen in the midregion. Fold originating anterior to the middle, low, and bearing in its median region a longitudinal depression occupied by a costa depressed below those bounding the fold. Costae forming margins of fold angular and strong; flanks narrowly rounded and with steep slopes.

Measurements in mm.—Holotype, length 5.8, brachial length 5.4, width 6.2, hinge width 1.9, thickness 4.1.

Type.—Holotype: 111317.

Horizon and locality.—Mosheim formation in Alabama: $\frac{1}{2}$ mile east of Oden-ville, Springville (30') Quadrangle.

Discussion.—This species differs from *S. perplexa* in its small size and the presence of strong costae at the anterior.

STENOCAMARA PERPLEXA Cooper, new species

Plate 111, E, figures 41-45; plate 119, C, figure 8; plate 268, H, figures 33-40

Shell of moderate to large size for the genus, length and width about equal; widest anterior to the middle. Hinge narrow; outline triangular to ovate; sides gently curved; anterolateral extremities narrowly rounded; anterior margin truncated, sides and pedicle beak forming an angle of about 93° . Valves unequally convex, the brachial valve having the greater depth. Surface smooth.

Pedicle valve gently convex in lateral and anterior profiles; umbo and antero-umbonal region gently swollen; sulcus broad and shallow, originating at about the valve middle; tongue short and squarish. Surface of sulcus convex; sulcus

bounded by short, narrow, and oblique costae. Flanks gently convex and sloping steeply to the sides. Dental plates long, extending for about one-quarter the length.

Brachial valve moderately convex in lateral profile, strongly and somewhat narrowly convex in anterior profile; beak narrow and long, curved over the inter-area of the pedicle valve. Umbo narrow and swollen; posteromedian region swollen; fold originating just posterior to the middle, narrow, steep sides and with flattened surface; midline of fold marked by a slight depression; fold bounded by narrow and fairly deep sulci; flanks narrowly rounded and with steep slopes.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 14.4 | 13.7 | 14.7 | 4.5 | 11.3 |
| Paratype (123289) | 11.8 | 11.5 | 11.0 | 3.8 | 6.8 |

Types.—Holotype: III1321; figured paratypes: III1322a, 123289; unfigured paratypes: III1318a-h, III1322b,c.

Horizon and locality.—Ellett formation (55 feet above the base) in Virginia: On Indian Run, $\frac{3}{4}$ mile northwest of Lusters Gate, Blacksburg (15') Quadrangle.

Mosheim limestone in Tennessee: $\frac{1}{2}$ mile east of the railroad station just east of Morristown, Morristown (T.V.A. 163-NE) Quadrangle; along the Southern RR. $\frac{3}{4}$ mile south of Mosheim, Mosheim (T.V.A. 181-NW) Quadrangle; Climer Post Office, 7 miles east of Cleveland, Benton (T.V.A. 126-NW) Quadrangle.

Same limestone in Alabama: $\frac{1}{4}$ mile southwest of Newhope Church, Vandiver (15') Quadrangle; $\frac{1}{2}$ mile east of Odenville, Springville (30') Quadrangle.

Discussion.—This species is characterized by its oval or pentameral outline, the elevated and abrupt median fold, and moderately deep sulcus. It is larger than *S. bicostata* and completely unlike that species.

Family PARASTROPHINIDAE Ulrich and Cooper, 1936

Syntrophoidea having a spondylium duplex and a cruralium duplex of sub-parallel brachiophore plates with alate processes.

Subfamily PARASTROPHININAE Schuchert, 1929

Parastrophinidae having a cruralium duplex.

Genus PARASTROPHINA Schuchert and LeVene, 1929

Parastrophia HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 221, 1893.

Parastrophina SCHUCHERT and LEVENE, Amer. Journ. Sci., vol. 17, p. 121, 1929.—ST. JOSEPH, Geol. Mag., vol. 78, No. 5, p. 371, 1941.

PARASTROPHINA BERNENSIS (Sardeson)

Camarella bernensis SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 328, pl. 4, figs. 4-6, 1892.

Anastrophia ? *hemiplicata* WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 382, pl. 30, figs. 29-31, 1893.

This name is revived for specimens from the Prosser limestone commonly referred to *P. hemiplicata* Hall. All the specimens from Minnesota, Wisconsin, and Iowa in the National Collections referred to Hall's name are clearly a different species from the New York one. Winchell and Schuchert mention that their specimens differ from New York examples "in having the umbo of the dorsal valve more tumid and elevated beyond that of the ventral valve. The transverse diameter in the former [Minnesota specimens] is also shorter, while the individuals are commonly smaller than those from eastern localities."

A fine specimen in the National Collections (24209) labeled *Camarella bernensis* by C. W. Hall indicates a more circular species than *P. hemiplicata* in its present average form. Hall's label further states that "The type is from Berne, Minn.—It is unfortunately an immature specimen a little distorted."

It is evident from the few specimens in the National Museum that *P. bernensis*, like other species of the genus, is also a very variable species. These species to be satisfactorily delimited will have to be restudied on the basis of large collections.

PARASTROPHINA BILOBATA Cooper, new species

Plate 118, D, figures 30-44; plate 119, A, figures 1-5

Shell small, subcircular outline; valves nearly equal in depth; sides rounded; anterior margin indented medianly; anterior commissure broadly uniplicate; lateral commissure straight; surface paucicostate, with 3 or 4 costae in the sulcus, 3 or 4 on the fold, and about 3 on the flanks.

Pedicle valve unevenly convex in lateral profile, the posterior quarter moderately convex in the umbonal region, the median half nearly flat and the anterior half moderately convex; anterior profile broadly and gently convex and with moderately steeply sloping lateral slopes. Umbonal region and area just anterior to it strongly swollen; sulcus originating at the middle, shallow and narrow but deepening suddenly near the anterior margin. Sulcus with a median trough forming the deepest part and flanked by costae which are depressed below the strong, narrowly rounded costae bounding the sulcus. Tongue short, truncated. Interior with wide and deep spondylium supported by a short, stout median septum.

Brachial valve fairly evenly and moderately convex in lateral profile; anterior profile broadly convex with the top somewhat flattened and steeply descending sides; fold originating at about the middle, low and indistinct throughout its length; median part of fold depressed into a narrow and moderately deep sulcus containing a single costa; anterior of fold deeply indented by above-mentioned median sulcus and forming the deep emargination characteristic of the species. Flanks inflated and with steep slopes. Interior with narrow and deep notothyrial cavity; cruralium elongate, septum short; brachioophores short; alate plates well developed; supporting plates often thickened particularly at or near junction with alate plates. Adductor field elongate; posterior pair of adductor scars small, an-

terior pair elongate; median septum continued forward as a low median ridge anterior to the anterior end of the adductor field.

Measurements in mm.—Holotype, length 4.4, brachial length 4.2, width 5.0, hinge width 1.6, thickness 3.0.

Types.—Holotype: 117166b; figured paratypes: 117166a,c-f,h-j; unfigured paratype: 117166g.

Horizon and locality.—Lower 3 feet of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Perry, Blocton (15') Quadrangle.

Discussion.—This species is quite unlike any other member of the genus yet described. It is the smallest species of the genus known, the largest specimen having a width slightly greater than 6 mm. It is particularly characterized by the anterior emargination produced by the sulcus within the median fold of the brachial valve.

PARASTROPHINA HEMIPLICATA (Hall)

Plate 106, G, figures 33-44; plate 117, D, figures 19-27

Synonymy: For full synonymy of this species up to 1915, see R. S. Bassler, Bibliographic index of American Ordovician and Silurian fossils, U. S. Nat. Mus. Bull. 92, p. 945. When using this synonymy several citations should be excluded. One such is *Anastrophia ? hemiplicata* Winchell and Schuchert. The citation under *Parastrophia hemiplicata* Schuchert, Proc. U. S. Nat. Mus., vol. 22, 1900, p. 158, refers to Baffin Land specimens that were described by S. K. Roy in 1941 as *P. hemiplicata minor*. Roy also determined the age of the beds in which these specimens occurred as late Ordovician. The references to *Camerella bernensis* should also be excluded. This seems to be a valid species (see above).

The following references from 1915 to the present writing should be added:

Camerella hemiplicata (Hall) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 168, pl. 25, figs. 3, 4, 6, 9-11, 16, 24, 43, 1932.

Parastrophina hemiplicata (Hall) KAY, Bull. Geol. Soc. Amer., vol. 48, p. 330, pl. 9, (Hull), 1937.—St. JOSEPH, Geol. Mag., vol. 78, No. 5, p. 377, text figs. 3-5, 1941.

Moderately large, transversely subelliptical in outline; valves of unequal depth, the brachial valve having the greater depth; posterolateral margins straight; sides narrowly rounded; anterior margin truncated; anterior commissure uniplicate; surface paucicostate, the fold having 3 to 5 costae, the sulcus 2 to 4, and the flanks 2 or 3.

Pedicle valve gently convex in lateral profile; anterior profile very broadly and gently convex; umbonal and median regions swollen; sulcus originating at the middle, wide, shallow, forming a short serrate tongue. Flanks somewhat swollen.

Brachial valve moderately convex in lateral profile with the greatest convexity in the umbonal region. Anterior profile strongly bowed, with steep lateral slopes. Umbo and median region swollen; fold originating at the middle, low in some specimens with the median costae depressed slightly below those forming the outer margins of the fold; flanks swollen and with steep slopes.

Measurements in mm.—

| | | Length | Brachial length | Width | Hinge width | Thickness |
|----------|----------------|--------|--------------------|-------|----------------|-----------|
| Hypotype | (117168b)..... | 10.4 | 10.5 | 12.9 | 2.5 | 8.0 |
| " | (117168a)..... | 10.9 | 10.8 | 12.9 | 2.4 ? | 8.5 |

Figured hypotypes.—II7168a-c; III324.

Horizon and locality.—Lower Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia County Highway 617=910, 0.15 miles north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—The foregoing description is based on five specimens from the base of the Martinsburg (Salona) shale at Green Mount Church north of Harrisonburg, Va. This is a rare shell in Virginia, and the characters of the specimens at hand are not in complete conformity with those of the specimens referred to this species from New York and elsewhere.

The National Museum collection of *Parastrophina hemiplicata* is small and unsatisfactory, but even so, it shows clearly that considerable revision is needed in this genus. The specimens from Watertown, N. Y., a locality mentioned in Hall's original description of the species, are fairly small shells having a length of 11 or 12 mm. and a width of 12 to 15 mm. The Virginia shells are somewhat smaller and somewhat rounder than those from Watertown. The latter specimens are quite different from large ones from Salona, Pa., and Larrabee Point, Vt., which have a width of 19 mm. Other specimens from Montreal, Quebec, are not unlike the Watertown shells but have different ribbing characters. The National Collection specimens, unfortunately, do not have detailed stratigraphic information, but the variety of forms indicates beyond doubt that they represent numerous levels and that geographic variation also plays a role of importance. The species is in need of revision, but this cannot be done without very extensive collections. The identification of the Virginia specimens is thus a tentative one.

PARASTROPHINA ROTUNDIFORMIS (Willard)

Plate 117, A, figures 1, 2

Anastrophia (?) *hemiplicata* var. *rotunda* WINCHELL and SCHUCHERT, Minnesota Geol. Surv., vol. 3, pt. 1, p. 383, pl. 30, figs. 32-35, 1895.

Parastrophina hemiplicata rotunda (Winchell and Schuchert) BASSLER, U. S. Nat. Mus. Bull. 92, vol. 2, p. 945, 1915.

P. rotundiformis WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 290, 1928 (not the Virginia specimens).

The shells from McNutt Quarry, near Sharon Springs, Va., and probably those from Thomas Farm, 3 miles east of Blacksburg, Va., from the Effna formation undoubtedly belong to *Perimecocoelia* and should not be identified with the Minnesota species which comes from the Trenton (Prosser) formation.

The specimen figured is exceptional for the fine development of the interior details.

Figured specimen.—87600.

Horizon and locality.—Prosser formation (*Prasopora* bed), in Iowa: 1½ miles north of Waukon, Allamakee County.

PARASTROPHINA sp. 1

Plate 106, F, figures 27-32

Shell small, subcircular in outline, brachial valve deeper than the pedicle one; fold low, marked by 2 strong subangular costae; sulcus moderately deep, narrow, marked by a single strong costa; flanks of pedicle valve gently swollen and with 3 short costae; flanks of brachial valve swollen and with 2 costae.

Measurements in mm.—117169, length 7.3, brachial length 7.4, width 8.6, thickness 5.7.

Figured specimen.—117169.

Horizon and locality.—Lower Martinsburg formation (part with *Brognartella*=Salona) in Virginia: On Virginia County Highway 617=910, 0.14 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This peculiar specimen seems to be a *Parastrophina* rather than a *Camerella* because of its fairly circular form and the shortness of its sulcus and fold. Naturally, a section of the beak is the only conclusive means of demonstrating the true generic characters. Possibly it is an aberrant form of the specimens called *Parastrophina hemiplicata*, but too few members of that species have been found in Virginia to permit the making of a series. Wilson (1914, pl. 4, figs. 4, 5) illustrates two specimens of *P. hemiplicata* having a single costa in the sulcus, but her specimens are much wider than the Virginia ones.

PARASTROPHINA sp. 2

Shell of about medium size, comparable to the medium-sized specimens of *P. hemiplicata*. Transversely and broadly elliptical in outline, paucicostate, the fold marked by 3 costae and the sulcus occupied by 2 costae. The flanks of the brachial valves have 2 costae. The specimen suggests *Perimecocoelia semicostata*, but the abraded beak of the brachial valve shows alate plates in cross section. The species is unlike any other Virginia specimens of *Parastrophina* in the collection in its anterior plication.

Measurements in mm.—111323, length 10.1, brachial length 10.6, width 13.1, thickness 7.3.

Described specimen.—111323.

Horizon and locality.—Oranda formation in Virginia: $\frac{1}{8}$ mile north of Green Mount Church, Broadway (15') Quadrangle.

Family PORAMBONITIDAE Davidson, 1853

Syntrophoidea with thick subparallel plates in both valves defining deep umbonal cavities. Exterior usually pitted.

It is doubtful if the shells assigned to *Porambonites* from the Table Head series and the upper part of the Pogonip formation in Nevada are actually congeneric with *Porambonites*. The known interiors from the Pogonip formation suggest relationship to *Noetlingia* rather than *Porambonites* in the presence of a well-formed spondylium in the pedicle valve, but they do not have the unusually wide hinge characteristic of the Russian genus.

Genus **PORAMBONITES** Pander, 1830

Porambonites PANDER, Geogn. Russ. Reiches, p. 95, 1830.—TEICHERT, Neues Jahrb. Mineral., Geol. and Paleont., Beil., Bd. 63, Abt. B, p. 177-246, 1930.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 102, 1932.

PORAMBONITES ? UMBONATUS Cooper, new species

Plate 107, B, figures 4-11

Porambonites ? sp. ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 242, pl. 53C, fig. 21 (not 27), 1938.

Shell large, wider than long, broadly elliptical in outline; valves subequally convex. Lateral margins broadly rounded; anterior margin subnasute; anterior commissure uniplicate. Surface marked by rows of small pits separated by fine costellae, about 3 of the latter in 1 mm. near the anterior margin of the brachial valve.

Pedicle valve moderately convex in lateral profile with the maximum convexity slightly posterior to the middle; anterior profile broadly convex; umbonal and median regions swollen; sulcus originating at the middle, shallow, wide, not increasing greatly in depth anteriorly. Tongue long, wide, and narrowly rounded. Flanks moderately swollen and with moderately steep slopes.

Brachial valve gently convex in lateral profile, with the umbonal region rounded but the anterior two-thirds flattened. Fold low, somewhat narrowly rounded, originating at the middle. Umbo and median region inflated; flanks moderately inflated and with moderately steep slopes. Interior with 2 widely divergent brachiophore supporting plates.

Measurements in mm.—Holotype, length 23.2, brachial length 22.8, width 27.3, hinge width 12.9, thickness 14.2.

Types.—Holotype: 111373a; figured specimen: 102310.

Horizon and locality.—Pogonip group (lower part *Rhysostrophia* zone) in Nevada: About 1 mile above the mouth of Ikes Canyon, south side of canyon, Toquima Range, Roberts Mountains (1°) Quadrangle.

Same formation in California: In Nopah Range, Inyo County.

Discussion.—This species proved to be very rare in the Ikes Canyon locality. It is characterized by its low fold and shallow sulcus and the fine ornamentation. It differs from *P. reticulatus* Pander in the first two of the above characters. It also differs in having widely divergent brachial plates rather than nearly parallel ones.

PORAMBONITES ? sp. 1

Plate 108, H, figures 40-42

Represented by one complete but crushed pedicle valve and another fragmentary pedicle valve showing sessile spondylium. Syntrophoid in habit, wider than long, with narrowly rounded sides. Lateral profile moderately convex; anterior profile broadly convex; tongue short, narrowly rounded. Flanks gently inflated and with moderate slopes. Teeth long, sharp, dental plates strong, anterior of sessile spondylium thickened, tapered, and elevated; median ridge not

protruding anterior to spondylium. Exterior marked with strong rows of pits separated by narrow costellae.

Measurements in mm.—117177, length 14.0, width 19.1.

Figured specimen.—117177.

Horizon and locality.—Pogonip group in California: In the hills on the west side of Racetrack Valley opposite Quartz Spring, Uhebe Peak (15') Quadrangle.

Discussion.—This species, of which only a single good pedicle valve is known, is smaller, more transverse, and more coarsely ornamented than *P. ? umbonata*. It is probably from a lower horizon although its precise position is not known.

PORAMBONITES ? sp. 2

Plate 107, A, figures 1-3

Length and width about equal, subhexagonal in outline; sides narrowly rounded; posterolateral margins straight, forming an angle of about 120° ; anterolateral margins nearly straight and continuous with the sharply pointed tongue. Umbonal region swollen; sulcus originating on the umbo, shallow, narrow, but widening and deepening anteriorly but not attaining more than a third the width. Flanks moderately convex with steep posterolateral slopes. Surface finely costellate and pitted but details indistinct in this specimen. Interior with stout dental plates; sessile spondylium thickened anteriorly but only slightly elevated at the front; median ridge short and thick. Adductor field an oval scar at the anterior end of the sessile spondylium.

Measurements in mm.—117179, length 19.1, width 20.8.

Figured specimen.—117179.

Horizon and locality.—Lower Table Head series in Newfoundland: At Table Point.

Discussion.—This species has a syntrophoid appearance like that of the preceding specimen, but the ornamentation seems to be finer and the sulcus is longer and narrower.

PORAMBONITES ? sp. 3

Plate 106, D, figures 17-24

Three specimens of a third species referable to *Porambonites?* were taken from the *Orthidiella* zone in Nevada. The fine ornamentation and small pits suggest that all the specimens are immature. The largest is 8 mm. wide by 6 mm. long, but the margins are crushed. At its front margin this specimen has 4 or 5 costellae in 1 mm.

The other two specimens come from the siliceous residues produced by digestion of limestone from the *Orthidiella* zone east of Frenchman Flat. The largest specimen is probably a pedicle valve and is 4 mm. wide by $3\frac{1}{2}$ mm. long. Inside it has two somewhat divergent dental lamellae bounding a fairly wide and deep delthyrial cavity. The floor of the cavity between the plates is slightly thickened. The third specimen is a fragmentary one and is interpreted as the posterior part of the brachial valve. In this one the plates are shorter and are inclined toward each other slightly. The thickening between them is greater than that of the

former specimen. Neither specimen gives clear indications of its true generic affinities.

Figured specimens.—111371a,b; 117178.

Horizon and locality.—Pogonip group (*Orthidiella* zone) in Nevada: In the first ridge east of Frenchman Flat, Las Vegas (1°) Quadrangle; about 1 mile above the mouth of Whiterock Canyon, Monitor Range, Roberts Mountains (1°) Quadrangle.

PORAMBONITES ? sp. 4

Plate 107, C, figures 12-14

A crushed specimen of this genus, probably a brachial valve, is 13 mm. long and 15.8 mm. wide. The valve is swollen and tumid, particularly in the umbonal region. It is very delicately ornamented, having 4 to 6 costellae in 1 mm. at the front. The umbonal region is very finely ornamented. Pits fine, about 5 to the millimeter at the front.

Figured specimen.—Columbia Univ. 26404 (1093).

Horizon and locality.—Salona formation in Pennsylvania: From the roadside and small quarry on Pennsylvania Highway 44, 150 yards east of the road to Oriole, east of Antes Gap, Williamsport, (15') Quadrangle.

Discussion.—This genus is very rare in any of the known Ordovician rocks of the eastern United States. The specimen here figured is not well enough preserved to describe. Dr. G. Marshall Kay who found it identified the beds from which it was taken as Upper Rodman, but it occurs in shaly beds that seem best referred to the lower part of the Salona formation.

Suborder PENTAMEROIDEA Schuchert and Cooper, 1931

Superfamily PENTAMERACEA Schuchert, 1896

Family PARALLELELASMATIDAE Cooper, new family

Shells having a spondylium duplex in the pedicle valve. Brachial valve provided with long subparallel plates defining a deep notothyrial cavity.

PARALLELELASMA Cooper, new genus

(Greek *parallelos*, parallel; *elasma*, plate)

Shell $\frac{1}{2}$ inch in length or longer, irregularly pentagonal in outline with narrow beaks and a wide anterior. Rectimarginate to broadly and indistinctly uniplicate. Biconvex; valves subequally deep; interareas reduced or obsolete; delthyrium open; ornamentation paucicostate, the posterior smooth and the anterior costate.

Pedicle interior with long, curved, slender teeth; notothyrial cavity V-shaped, defined by thin, delicate dental plates that unite with the median septum to form a spondylium; anterior of spondylium produced into an elongate, narrowly rounded, concave tongue. Median septum, high, slender, prolonged anterior to the spondylium, not extending to the middle.

Brachial valve with deep and narrow notothyrial cavity; brachiophores short,

slender, nearly straight; fulcral plate long and slender forming a deep trough on the outside of the brachiophore; posterolateral face of brachiophore thickened and overhanging socket, terminating in a fairly long triangular accessory tooth. Brachiophore plates long, high, slender, confined to the posterior quarter or less; muscle scars not seen.

Genotype.—*Parallelelasma pentagonum* Cooper, new species.

Discussion.—This genus shows many peculiar characters, both internal and external. The inner anatomy suggests relationships to *Salonia*, *Metacamarella*, and to *Pentamerus* itself. It is a remarkably complicated pentamerid for one of the earliest known.

At first glance the exterior of this genus suggests a camerellid. It is much narrower and more attenuated at the beaks than is normal in that genus. It also flares out anteriorly and has straighter posterolateral sides than is usual in *Camerella*. The sides of both valves of *Parallelelasma* are inflected and flattened or concave. In side view the genus, in its posterior half or two-thirds, would have a very compressed appearance. The lateral commissure is often broadly serrate to the point where the pedicle tongue appears. Here the right-angled inflection is terminated. At the place where the flattened lateral area terminates is a narrow gap in the pedicle valve to receive the lobe marking the anterior termination of the lateral inflection of the brachial valve. The pedicle tongue is short and broadly rounded. The anterior commissure of the brachial valve is either rectimarginate or with a broad wave to fit the broadly rounded and serrate pedicle tongue. The material available does not show a marked anterior broad fold as is usual in many pentameroids.

The exterior is paucicostate. The posterior half or less is smooth, but the anterior half or more is marked by broad, low, rounded costae. These present no unusual features as they appear on the body of the shell, but their terminations along the anterior margins of both valves are unusual. The fairly strong costae terminate in deep reentrants, while the grooves between the costae end in long, sharp projections to produce a jagged margin. The reentrants are of particular interest.

The costated anterior edge is modified to form an elaborate type of strainer. The edge of the reentrant is deflected anteriorly to form a low marginal wall. Across the reentrants of each valve a sort of shelly diaphragm is built slightly obliquely from the shell surface. These diaphragms across the reentrant combined with the low wall built around the entrant define small chambers at the ends of the costae. The costae are alternate in arrangement which permits the acute projection extending from the troughs to fit into the chamber at the end of the reentrant. The end of the trough fits over the diaphragm closing the reentrant. This neat device forms a very efficient straining device for the food-bearing currents entering the valve.

The interior of the pedicle valve shows no unusual features. The spondylium is short, fairly shallow and has a long anterior projection at its free end. The articulating process or tooth is of interest because it is so long and slender. Another feature of interest in connection with the articulation of the pedicle valve

is the slender fold of the shell on the outside of the tooth, which leaves a narrow slot. This fits against the angulated edge of the brachial valve. No trace of muscle marks was seen in the spondylium. Narrow interareas appear on each side of the delthyrial cavity. In old specimens the edge of the shell from the interarea anteriorly for some distance is flattened and slotted to take the edge of the opposite valve.

The interior structures of the brachial valve are of considerable interest. These have a strong resemblance to the cardinalia of *Pentamerus* and allies, but a number of important differences can be seen. A long and deep socket divides the outside wall of the shell from the brachiophore. The base of the socket is defined by a deeply concave fulcral plate. The brachiophore is a flat, short, sharply pointed straight blade bounding the socket and, by its progressive growth, forming a ridge bounding the notothyrium. The outer edge of the brachiophore is thickened along the socket wall, and opposite the end of the socket it terminates in a fairly long triangular tooth. This process fits on the inside of the tooth of the pedicle valve and helps to keep the two valves fitted in place. The brachiophore supporting plates are high and slender but short, being confined to the posterior quarter or less of the valve. Not one specimen in the collection showed any trace of the muscle field. However, low ridges between the brachiophore plates on a few specimens suggest that the muscles were confined to the notothyrial cavity.

A structure of interest in the brachial valve is the small ridge on each side of the beak at the posterior of the valve. This extends obliquely from the beak to the posterior termination of the socket. It overlies and crosses the posterior end of the brachiophore. Its use to the brachiopod is not immediately apparent.

The chief similarity between *Parallelelasma* and *Pentamerus* is the presence in each of the nearly parallel brachiophore supporting plates. Here the similarity ends because the cardinalia of the Ordovician genus are not divisible into inner and outer plates like the cardinalia of *Pentamerus*. The inner plates of the latter produce a broad divided hinge plate and shallow notothyrial cavity. Furthermore, the brachial process is given off at the anterior end of the vertical plate deep inside the valve. Similar difficulties confront a comparison with members of the Gypidulinae.

The exteriors of the Pratt Ferry genus and *Salonia* are totally unlike except in the beak region and the compressed marginal areas. Inside the brachial valve the similarity consists, in the main, of the presence of two long and subparallel plates. The cardinalia are actually not very close. The important difference between them is in the length and form of the brachial process, which is long and expanded in *Salonia* but short and straight in *Parallelelasma*. This feature also constitutes the chief difference between the Alabama genus and *Metacamarella* from the Girvan District, Scotland.

The exterior of *Metacamarella* is very similar to that of *Parallelelasma*, but sufficient characters are known to establish the two as independent genera. The exterior of *Metacamarella* is paucicostate like that of the Alabama shell, but the costae are more concentrated in the median region to form a low, indistinct fold

on each valve. The sides are compressed in both genera, and the shells are narrowed posteriorly but much more so in the American genus. Cowper-Reed describes the exterior of *Metacamarella* as "externally punctate." All available evidence indicates that the exterior of *Parallelelasma* is smooth.

Through the kindness of Dr. Helen M. Muir-Wood of the British Museum, who has examined the types of *Metacamarella* preserved in the British Museum, it is possible now to say that the Scottish genus is not punctate on the exterior. Dr. Muir-Wood says "Most of the specimens are much decorticated and the shell tends to weather in overlap scales but these do not appear punctate. The shell is very finely fibrous, the fibres running obliquely to the surface in the outer layers, and the broken off ends of the fibres do give the shell a somewhat granular appearance which may be taken for punctation."

St. Joseph (1941, p. 399) does not mention presence of exopunctae in his discussion of the genus. The five sections of the brachial valve illustrated show well the subparallel plates of the brachial valve, and low ridges between these plates suggest that the muscles were confined between these plates as in *Parallelasma*. Unfortunately, no illustration of the "crura" is given.

Metacamarella has short, subparallel plates like those of *Parallelelasma* in the brachial valve, but the cardinalia are described as having long, stout crura, recurved and diverging at about 60°, close to the hinge line. This is quite unlike the short, straight brachial processes of the Alabama genus. It is concluded therefore that *Metacamarella*, although superficially like *Parallelelasma*, is a distinct genus but probably belongs in the family Parallelelasmataidae.

PARALLELELASMA PENTAGONUM Cooper, new species

Plate 115, H, figure 49; plate 118, B, figures 11-19; plate 119, F, figures 17-31;
plate 121, A, figure 1

Shell thin, elongate, pentagonal in outline with a narrow posterior but a wide anterior; lateral margins obliquely straight for about two-thirds the length; anterolateral extremities angulated; anterior elongate and broadly rounded. Biconvex, the brachial valve somewhat deeper than the pedicle valve; anterior commissure rectimarginate to broadly uniplicate. Lateral commissure broadly serrate anteriorly. Beaks low, somewhat closely appressed. Posterior third smooth, anterior two-thirds marked by broad, low, rounded costae. Lateral edge narrowly angulated and somewhat produced and elevated at its anterior end.

Pedicle valve gently convex in lateral profile; broadly and gently convex in anterior profile; umbonal region narrowly swollen; median region gently inflated; margins deflected slightly and separated by a narrow, shallow sulcus; region between two sulci forming a broad ill-defined sulcus.

Brachial valve gently convex in lateral profile, somewhat more convex posteriorly than in the anterior half; anterior profile broadly and gently convex. Umbonal region narrowly swollen; median region gently inflated. Lateral slopes narrowly rounded and precipitous. Costae anteriorly forming an ill-defined fold.

Interior as defined under the genus.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Greatest width | Thickness |
|-------------------------------------|--------|-----------------|----------|----------------|-----------|
| Paratype (pedicle valve 117156e) .. | 13.7 | ? | 10.0 | 14.8 | 5.8 |
| " (brachial valve 111329) .. | ? | 14.3 | 11.5 | 14.7 | 5.5 ? |

Types.—Holotype: 117156-1; figured paratypes: 111329, 117155b,c,e-g, 117156a,c-h,j; unfigured paratypes: 117155a,d, 117156b,i,k,m.

Horizon and locality.—Lower 3 feet of the Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other shell is quite like this one except for species of *Idiostrophia*. The latter have the elongate form and pentagonal outline of *Parallelasma* and the peculiar flattening of the margins, but the interiors of the two genera are so different that little confusion will result.

Genus *SALONIA* Cooper and Whitcomb, 1933*SALONIA MAGNAPPLICATA* Cooper and Whitcomb

Plate 107, D, figures 15-21

Salonia magnaplicata COOPER and WHITCOMB, Journ. Washington Acad. Sci., vol. 23, No. 11, pp. 500-503, 1933.

Figures of this species are introduced for comparison with those of *Parallelasma*. The presence of the long subparallel brachiophore supporting plates indicates relationship between the two genera. They differ mostly in exterior ornamentation and form but also in one important interior feature. The brachial processes of *Salonia* are long, flat, somewhat curved blades, whereas those of *Parallelasma* are short, straight, and blunt.

Types.—Holotype: 85422a; paratypes: 85422b-e,p.

Horizon and locality.—Salona formation (12 feet above the base) in Pennsylvania: Along the railroad beside Fishing Creek in Salona, Clinton County, Lock Haven (15') Quadrangle.

DIDYMELASMA Cooper, new genus(Greek *didymos*, twin; *elasma*, plate)

Shell small, syntrophoid in appearance; uniplicate; surface paucicostate. Beaks small, interareas obsolete. Delthyrium open.

Pedicle interior provided with a narrow, short spondylium supported by a long, thin median septum.

Brachial interior with two long parallel plates supporting a long, thin, slightly curved brachial process, which is attached to a triangular socket plate located between the posterior edge of the brachial process and the posterior edge of the valve. Muscle scars not seen.

Genotype.—*Didymelasma longicrurum* Cooper, new species.

This genus is so far known only from the species described herein. It is a small shell having the appearance of a syntrophid. It has small beaks with no interarea remaining as far as can be determined. The species is not unlike that

of *Neostrophia gregaria* from the Bromide formation at Rock Crossing, Okla., but it can be readily differentiated from any of the known camerellids except *Metacamarella*, *Salonia*, and *Parallelelasma* by its brachial interior.

Didymelasma differs from *Metacamarella* in the form of the valves, the latter genus being elongate and flaring anteriorly. It differs internally in having a long and nearly straight brachial process rather than a long, curved one as described for *Metacamarella*.

Salonia is totally unlike *Didymelasma* in its transverse form and the strong anterior lobation. The brachial interior resembles that of *Salonia* in the presence of the long brachial process, but that structure in *Didymelasma* is given off from a more anterior point than in *Salonia* and the process is nearly straight.

The exterior of *Parallelelasma* has a distinctly pentagonal outline with the greatest width anterior to the middle and the shell strongly angulated at the place of maximum width. In these respects it is entirely unlike *Didymelasma*. Inside the brachial valve the position and great length of the brachial process in *Didymelasma* are important differences.

DIDYMELASMA ABRUPTUM Cooper, new species

Plate 120, E, figures 30-33

Shell small, subcircular in outline with length and width nearly equal; sides rounded; anterior commissure uniplicate; surface smooth.

Pedicle valve moderately convex in lateral profile and fairly strongly convex in anterior profile. Umbonal, median, and flank regions swollen; sulcus originating about $1\frac{1}{2}$ mm. anterior to the beak, shallow and narrow but widening anteriorly although not deepening greatly in the same direction. Old specimens with a faint costa at the anterior end of the sulcus. Tongue short. Interior with a median septum extending to about the middle.

Brachial valve gently convex in lateral profile, greatest convexity in the posterior third, anterior third somewhat flattened. Anterior profile broadly convex; umbonal and median regions full. Sulcus originating between the umbo and the middle, fairly strongly elevated at the front, flattened on top. Flanks swollen but strongly depressed below the level of the fold. Interior with two short, sub-parallel plates.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--|--------|-----------------|-------|-----------|
| Pedicle valve (C.U. 26403(928)a)..... | 5.5 | ? | 5.8 | 1.9 ? |
| Brachial valve (C.U. 26403(928)b)..... | ? | 5.3 | 5.3 | 1.7 |
| “ “ (C.U. 26403(928)c)..... | ? | 5.8 | 6.1 | ? |

Types.—Holotype: Columbia Univ. 26403(928)b; figured paratypes: Columbia Univ. 26403(928)a,c.

Horizon and locality.—Rockland formation in Ontario, Canada: Northeast of Gretna.

Discussion.—This is a larger species than the *D. longicrurum* of the Lebanon formation. Besides size it differs in the fold and sulcus, those of the Ontario form

being longer and more elevated. The sulcus of the Lebanon species is short and deep. The Tennessee species have a tendency to some costation on the front of the valves, which is seen only indistinctly in the Ontario form.

DIDYMELASMA LONGICRURUM Cooper, new species

Plate 120, D, figures 19-29

Shell small, syntrophoid in outline and profile, subcircular; sides rounded; anterior margin truncated; anterior commissure somewhat narrowly uniplicate; surface smooth but many specimens with indistinct costae in adults, usually 2 on the fold, 1 in the sulcus, 1 on the flanks near the middle.

Pedicle valve fairly strongly convex in lateral profile; broadly and moderately convex in anterior profile. Umbonal region somewhat narrowed at the beak; median region inflated; sulcus originating just anterior to the middle, abruptly deepening to become moderately deep at the margin; sulcus bounded by narrowly rounded costae; flanks somewhat swollen and with steep lateral slopes. Interior with small spondylium and long, thin median septum.

Brachial valve moderately convex in lateral and anterior profiles and with a depth about equal to that of the pedicle valve. Umbo narrow; median region swollen; fold narrow and rounded, moderately strongly elevated, originating at about the middle; sides of fold defined by moderately deep sulci. Flanks only gently inflated and with moderate lateral slopes. Interior with 2 parallel brachial plates and long, nearly straight brachial process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 3.75 | 3.7 | 4.2 | 0.5 | 2.3 |
| Paratype (117158d) | 3.5 | 3.4 | 3.75 | 0.49 | 1.3 |

Types.—Holotype: 117158c; figured paratypes: 117158a,b,d; unfigured paratypes: 117158e,f.

Horizon and locality.—Upper part of the Lebanon formation with *Doleroides tennesseensis* Cooper in Rutherford County, Tennessee: On U. S. Highway 41, $\frac{3}{4}$ mile southeast of Knox Branch, 9 miles southeast of Murfreesboro.

Discussion.—This species is characterized by its small size and syntrophoid form. It has a deep sulcus on the pedicle valve and a strong, elevated fold on the opposite valve. These latter features are more pronounced than in *D. abruptum* which has a broader fold and sulcus.

Superfamily RHYNCHONELLACEA Schuchert, 1896

Family PROTORHYNCHIIDAE Schuchert, 1896

Rhynchonellacea lacking complete deltidial plates but have dental lamellae, long curved crura, but no median septum or cruralium.

Subfamily PROTORHYNCHIINAE Schuchert, 1896

Protorhynchiidae of uncertain structure.

Genus *PROTORHYNCHA* Hall and Clarke, 1893

Protorhyncha HALL and CLARKE. Pal. New York, vol. 8, pt. 2, p. 180, 1893.

It is pointed out below that the type specimens of *Protorhyncha dubia* Hall have long been lost and the genus is virtually unknown. Raymond has pointed out that the type specimens may actually have been young hebertelloids, which makes the genus still more confusing. The facts are mentioned and discussed below. Until the types are found, or other specimens that can be definitely identified as *P. dubia*, the true characters of the genus will not be known.

Genotype.—*Atrypa dubia* Hall, Pal. New York, vol. 1, p. 21, 1947.

Subfamily ANCISTRORHYNCHINAE Cooper, new subfamily

Protorhynchiidae with characters of the family.

Genus *ANCISTRORHYNCHA* Ulrich and Cooper, 1942

Protorhyncha (part) HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 180, 1894.—

RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 226, 1911.—HAYES and ULRICH, Geol.

Atlas U. S., Folio 95, Faunal Chart, 1903.

Ancistrorhyncha ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 624, 1942.

Shell small, rhynchonelloid in outline and profile, valves subequal in depth; biconvex in profile; anterior commissure uniplicate. Surface marked by fine radial costae. Impunctate.

Pedicle valve with open delthyrium, vestigial interarea, incurved beak. Delthyrial cavity deep, bounded by strong dental plates separated from sides of valve by deep umbonal cavities; teeth small, curved. Details of musculature unknown.

Brachial valve with divided hinge plate; sockets deep, defined by a fulcral plate and a thin but elevated socket ridge; outer hinge plate slightly concave; crural base forming inner edge of outer hinge plate; crura long and slender, ending in a broad hooklike expansion pointing anterolaterally and at about right angles to the crus. Musculature unknown; median septum absent.

Genotype.—*Ancistrorhyncha costata* Ulrich and Cooper, Journ. Paleont., vol. 16, No. 5, p. 625, pl. 90, figs. 25-27, 30-31, 1942.

Discussion.—This genus is characterized by its rhynchonelloid exterior, fine regular costae, open delthyrium, strong dental plates, divided hinge plate, and long crura. It is distinguished from *Rhynchotrema* and *Rostricellula* by absence of a septum and cruralium and the fine, even nature of the ornamentation.

The members of this genus were formerly classified under the name *Protorhyncha*, but this name is no longer available for two reasons. First, the type species is unrecognizable, as type specimens have long been lost; second, the species used by Hall and Clarke for their description of the genus is still invalid.

Hall and Clarke designated *Atrypa dubia* Hall as the type of the new genus *Protorhyncha*, but as pointed out by Raymond (1911) this species is unrecognizable. Hall's definition of the species is very vague, his figures are poor indeed, and he states that the specimens are in the nature of casts, all of the shell having been removed. Only two or three individuals of the species are said to have been

known. Raymond suggests that "the original specimen may have been a young *Camarotoechia plena*, a young *Camarotoechia pristina*, or a broken and exfoliated *Hebertella*."

Although Hall and Clarke named *A. dubia* as type of their genus, they realized that the species on which it was based was poorly described because they did not use the type specimens to derive their generic diagnosis. Instead they used specimens from "the gorge of the Kentucky River, at High Bridge, Kentucky" which they erroneously identified as Hall's "*Atrypa*" *dubia*. This procedure of course, under the rules, has no bearing on the validity of their selection of *A. dubia* as the type of the genus.

To add still further to the confusion Hall and Clarke failed to refigure *Atrypa dubia* and also published no figures of the Kentucky specimens from which they derived their generic description. Instead they illustrated a Silurian species called *Protorhyncha aequiradiata* Hall which actually shows the chief generic characteristics of *Rhynchotrema* or *Camarotoechia* (pl. 56, fig. 8). The generic diagnosis and the species on which *Protorhyncha* is based thus prove to be vague and poorly founded, and this is true also of the species proposed by Raymond to serve as neotype.

In his discussion of *Protorhyncha* Raymond suggests that, inasmuch as the type species *P. dubia* is unrecognizable, the species from which Hall and Clarke derived their generic diagnosis be used as the type of the genus. This is the species identified by Ulrich as *Rhynchonella ridleyana* (Safford). The name *Rhynchonella ridleyana* was first used by Safford (1869, p. 287) without definition or other designation than to list it as having been taken from the Pierce and Ridley limestones. When Hall and Clarke prepared their generic description of *Protorhyncha*, they stated that their information was derived from specimens coming from High Bridge, Ky., but failed to use any specific name in connection with them, and it is therefore at least implied that they identified their specimens with *P. dubia* rather than *P. ridleyana*. In the Columbia Folio Ulrich (1903) uses the new combination *Protorhyncha ridleyana* for the first time in a list of characteristic fossils of the Ridley limestone but failed to furnish a definition of the species. This combination has been in use for some time not only for specimens from the Ridley limestone of central Tennessee but also for specimens from High Bridge, Ky. Although the name has long been in use, no definition of it has ever been prepared.

From the above remarks it will be seen that the definition of *Protorhyncha* is based on misidentified fossils and that the named type is unrecognizable. Furthermore, the attempt to establish *P. ridleyana* as type of the genus fails because that species is still a nomen nudum and without validity. The name *Protorhyncha* thus proves to be one of very dubious value, and it seems best to leave it with the unrecognizable specimens for which it was proposed and to supply a new name for the splendid material of several species that had hitherto been placed in *Protorhyncha*.

Ancistrorhyncha at present has no close relatives to which it may be compared. It is distinctly not the first of the rhynchonellids but a fairly highly specialized

brachiopod. The hooklike extension on the crura may be seen also in well-preserved specimens of *Lepidocyclus*, but there the similarity ends. The ornamentation of the genus is unlike that of typical rhynchonellids, and the absence of a septum in the brachial valve is also atypical for rhynchonellids.

ANCISTRORHYNCHA AUSTRALIS (Foerste)

Plate 127, E, figures 28-32; plate 127, F, figures 33-41; plate 127, G, figures 42-46

Protorhyncha dubia HALL and CLARKE (part), Pal. New York, vol. 8, pt. 2, p. 180, 1894.

Protorhyncha ridleyana RAYMOND (part), Ann. Carnegie Mus., vol. 7, No. 2, p. 226, 1911.

Catazyga uphami-australis FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 16, p. 31, pl. 2, figs. 19a, b; pl. 3, figs. 14a-c, 1910.

Shell small, subcircular in outline; beak forming an obtuse angle; sides somewhat narrowly rounded; front margin gently rounded. Surface marked by broad, rounded costae separated by spaces narrower than the costae, about 54 costae in all, with 11 in the sulcus.

Pedicle valve moderately convex in lateral profile with the greatest convexity in the posterior half; umbonal region swollen; beak strongly curved over the brachial umbo; sulcus short, shallow,^d originating slightly anterior to the middle, occupying less than half the width; tongue short, rounded. Flanks rounded, with fairly steep slopes to the margins.

Brachial valve fairly evenly convex in lateral profile, broadly convex in anterior profile. Umbonal and median regions swollen; fold a low, gentle swelling originating anterior to the middle, narrow. Flanks rounded, depressed below the fold; lateral slopes moderate.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Lectotype | 7.9 | 7.6 | 9.0 | 5.5 |
| Hypotype (111291a) | 7.7 | 6.7 | 8.4 | 4.3 |
| “ (111291c) | 8.7 | 7.8 | 10.6 | 5.5 |

Types.—Lectotype: 87043a; figured hypotypes: 111291a-c, Columbia University (no number).

Horizon and locality.—Camp Nelson formation in Kentucky: At High Bridge, Harrodsburg (30') Quadrangle.

Lebanon formation in Tennessee: Opposite the Fairview Service Station on U. S. Highway 70N, just west of Rome and 11.6 miles east of Lebanon, Smith County.

Nealmont formation in Pennsylvania: 1 mile west of Tusseyville, Centre Hall (15') Quadrangle; south of Pa. C. Ry., Bellefonte, Bellefonte (15') Quadrangle.

Discussion.—This species is characterized by its soft, rounded outlines, narrow fold and sulcus, and the fine, crowded costae. It is most like *A. costata* but differs from that species in its narrower fold and sulcus and the finer ornamentation. The fact that the finely costate forms outside of the High Bridge area are post-Ridley and Wardell, suggests that the level containing this species at High Bridge belongs to the Lebanon, Nealmont, and lower Trenton.

ANCISTRORHYNCHA COSTATA Ulrich and Cooper

Plate 126, B, figures 6-9; plate 127, H, figures 47-52; plate 127, J, figures 58-62; plate 129, A, figure 1; plate 129, B, figure 2; plate 129, C, figures 3-8; plate 129, D, figures 9-13; plate 129, E, figures 14-19; plate 129, F, figures 20-25; plate 129, H, figures 33-38

Ancistrorhyncha costata ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 625, pl. 90, figs. 25-27, 30, 31, 1942.

Shell small, valves subequal in depth, subtriangular to subpentagonal in outline; beak slightly greater than a right angle; sides diverging and straight from beak to about the middle where the shell attains its maximum width, sides rounded at middle; front margin truncated. Surface marked by low, rounded costae separated by spaces narrower than the costae. The sulcus is marked by 6 to 10 costae, the fold by 7 to 11 costae, and the flanks bear about 13 ribs.

Pedicle valve moderately convex in lateral profile with the greatest convexity located in the tumid posterior half. Sulcus originating at about the middle, shallow, with a short, narrowly rounded tongue; sulcus occupying as much as half the width at the front. Flanks fairly strongly rounded and with moderately steep slopes.

Brachial valve moderately convex in lateral profile and with the maximum curvature at about the middle; anterior profile fairly strongly rounded. Umbonal and median regions swollen; fold originating slightly anterior to the middle, low in most specimens and in some scarcely distinguishable. Flanks moderately rounded and with moderately steep slopes.

Interior: Dental plates strong, separated from inner wall of valve by umbonal cavities; crura long and slender.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 7.8 | 6.7 | 8.6 | 5.0 |
| Hypotype (117204b) | 8.5 | 7.7 | 10.0 | 6.0 |
| " (117204a) | 9.0 | 8.0 | 10.0 | 6.5 |
| " (117205) | 7.4 | 6.8 | 7.7 | 4.4 |
| " (117204c) | 7.2 | 6.5 | 7.7 | 4.9 |
| " (111196) | 6.9 | 6.6 | 7.6 | 4.8 |
| " (117206a) | 8.0 | 7.4 | 8.9 | ? |
| " (117206f) | 6.6 | 5.9 | 7.3 | 3.8 |

Types.—Holotype: 108203; paratypes: 108204a-1; 111183; figured hypotypes: 111196, 117204a,b,c, 117205, 117206b,c, 117207, 123291a, Columbia Univ. 25880(2120); measured hypotypes: 117206a,f.

Horizon and locality.—Ridley or Murfreesboro formation in Sequatchie Valley, Tenn.: 1½ miles southeast of Hembree Mill, Pikeville (15') Special Quadrangle; Crystal Creek, 5 miles south of Pikeville; Sequatchie Valley; Murfreesboro; Ridley formation: 0.6 mile south of Chappel Hill Methodist Church on Tennessee Highway 28, 1 mile south of its junction with Tennessee Highway 8.

Same formation in Rutherford County, Tenn.: Stone River bridge on Tennessee Highway 96, 1 mile west of Murfreesboro; east side of Marshall Knobs about 5 miles south of Murfreesboro.

Pierce formation in Rutherford County, Tenn.: at Nice's Mill, west fork of Stone River, 8 miles (airline) northwest of Murfreesboro; Pierce Mill at Walter-hill, on Tennessee Highway 10, $7\frac{1}{2}$ miles north of Murfreesboro.

Wardell part of Dryden formation in Virginia: In north quarry on Station Creek, $\frac{1}{2}$ mile south of U. S. Highway 58, 2 miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle.

Wardell and Wardell part of Dryden formation in Tennessee: 0.3 mile south-west of Little Barren Church, northwest corner of the Powder Springs (T.V.A. 154-SW) Quadrangle; Jacksboro, Jacksboro (T.V.A. 136-SW) Quadrangle; 1 mile west of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; north of canyon of Gap Creek, $1\frac{1}{4}$ miles west of Arthur, Cumberland Gap (T.V.A. 153-SW) Quadrangle; Raccoon Valley, 5 miles south of Clinton, Clinton (T.V.A. 137-SW) Quadrangle; 1 mile west of crest of Missionary Ridge, Chat-tanooga, Chattanooga (30') Quadrangle; hill back of Camp Loyston, Maynard-ville (30') Quadrangle; Little Mulberry Creek on road up Sycamore Valley, Back Valley (T.V.A. 161-SE) Quadrangle.

Peery formation (lower 8 feet) in Virginia: South side of Peery Lime Com-pany Quarry on Virginia Highway 61, North Tazewell, North Tazewell (T.V.A. 217-NE) Quadrangle.

Ridley formation in Kensington (T.V.A. 106-SE) Quadrangle, Georgia: 10 miles south of Chickamauga; on U. S. Highway 27, 4.2 miles north of Rock Spring; quarry on the west side of the road, $1\frac{1}{2}$ miles south-southeast of Cove Church, 5 miles south of Chickamauga.

Hostler formation in Pennsylvania: In the section between Rodman and Roaring Spring, Hollidaysburg (15') Quadrangle; National Lime Quarries, Shrader Station=Naginy P. O., Lewistown (15') Quadrangle.

Bromide formation (Pooleville member) in Oklahoma: 5 feet below the Viola contact in the road cut on Oklahoma Highway 99, NW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, T. 1 N., R. 6 E., 3 miles south of Fittstown, Pontotoc County. In Murray County, Okla., at base of bed 2 on Spring Creek, sec. 17, T. 2 S., R. 1 W.; in the *Tetradium* beds in the top 10 feet on Colbert Creek, SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 15, T. 1 S., R. 1 E., 3 to 4 miles southwest of Davis; E $\frac{1}{4}$ sec. 1, T. 2 S., R. 2 W., 3 miles east of Pooleville; 4 miles west and 2 miles south of Davis.

Pamelia formation (50 inches from top) in New York: Quarry east of rail-road bridge north of Mill Creek in Lowville, Lowville (15') Quadrangle.

Lower Platin group (Bloomsdale formation) in Missouri: On the Heck place, $1\frac{1}{4}$ miles south-southeast of River aux Vasses, Weingarten (15') Quadrangle.

Platin group in Arkansas: On east side of Arkansas Highway 69, 2 miles north of Cushman, Batesville (30') Quadrangle.

Discussion.—The material on which this species is based consists of fairly well preserved silicified specimens etched from limestone, as well as excellent speci-mens weathered from shaly seams in calcilutite or from calcilutite. The silici-fied specimens preserve the long crura of the brachial valve with the hooklike process on the extremity.

This species is characterized by its large size, attaining about the maximum known dimensions for the genus, the wide fold and sulcus, and the subtriangular form. It differs from *A. australis* (Foerste) by its stronger ornamentation, less strongly incurved beak, and less tumid brachial valve.

ANCISTORHYNCHA CRASSA Cooper, new species

Plate 99, I, figures 53-61; plate 127, D, figures 20-27; plate 127, I, figures 53-57;
plate 186, G, figures 26-31

Shell of about the usual size for the genus, slightly wider than long with the greatest width at about the middle. Beak obtuse, posterolateral margins short; lateral margins narrowly rounded; anterior margin truncated. Surface marked by about 30 rounded costae separated by spaces equal in width to the width of the costae. Four or five costae occupy the sulcus, 5 or 6 are on the fold, and about 12 on the flanks.

Pedicle valve moderately convex in lateral profile with the greatest convexity at about the middle; beak moderately incurved; sulcus originating about one-third the length from the beak, shallow and narrow, occupying less than half the width at the front; tongue short and narrowly rounded. Flanks slightly convex and with moderate slopes to the margins. Umbonal region and posterior half of valve somewhat inflated.

Brachial valve of about the same depth as the pedicle valve, moderately convex in lateral profile and with greatest convexity in the umbonal region. Anterior profile only moderately convex. Umbo marked by a shallow and narrow sulcus for one-third the length from the beak, after which the median fold develops; fold low, narrow, posteriorly spreading at the front; flanks broad and rounded in profile, with moderate slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 8.2 | 7.5 | 9.5 | 5.0 |
| Paratype (111178b) | 7.0 | 8.5 | 7.9 | 4.6 |

Types.—Holotype: 111178a; figured paratypes: 111178b; 111184a, 117208a; Columbia Univ. 26407(1016); unfigured paratypes: 111184b, 117208b.

Horizon and locality.—Peery formation in Tennessee: On Clinton (T.V.A. 137-SW) Quadrangle, 7 miles southwest of Clinton; top of hill north of Elza Gate, Oak Ridge, Clinton (T.V.A. 137-SW) Quadrangle.

Wardell part of Dryen formation in Tennessee: Section 1 mile west of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle.

Ridley formation in Tennessee: On Tennessee Highway 28, 0.6 mile south of Chappel Hill Church, 1 mile south of junction with Tennessee Highway 8, Daus (T.V.A. 104-SW) Quadrangle.

Hostler? formation in Pennsylvania: 1 mile south of Covedale, Blair County.

Discussion.—This species differs from all other described ones in the strength of the costae covering the surface. In this respect it resembles *A. missouriensis*, but in that species the fold and sulcus are much less well defined than in *A. crassa*.

ANCISTRORHYNCHA GLOBULARIS Cooper, new species

Plate 128, B, figures 6-9

Shells small, rotund and circular when young, somewhat wider when adult; length and width about equal; beak obtuse; sides rounded; front margin truncated. Surface costate, with 18 to 24 costae, of which 4 to 6 occupy the sulcus.

Pedicle valve evenly and fairly strongly convex in lateral profile with the greatest convexity at about the middle. Beak short and inconspicuous, incurved; umbonal and median regions swollen; sulcus originating at the middle, shallow, equal to about half the width at the front margin. Flanks rounded and with steep lateral slopes.

Brachial valve not quite so deep as the pedicle valve; moderately convex in lateral and anterior profiles; median and umbonal regions slightly swollen; fold low, often difficult to distinguish; flanks well rounded and steep lateral slopes.

Measurements in mm.—Holotype, length 4.8, brachial length 4.1, width 5.0, thickness 3.2.

Types.—Holotype: 111278a; unfigured paratypes: 111278b,c.

Horizon and locality.—Bromide formation (Pooleville member) just below the Viola in Oklahoma: 4 miles west and 2 miles south of Davis, Murray County.

Discussion.—This species is the smallest of those yet described and differs from all others in its globular form, straight front, and considerable thickness. It is readily distinguished from *A. costata*, with which it occurs, by its smaller size and less transverse shells.

ANCISTRORHYNCHA MISSOURIENSIS Cooper, new species

Plate 128, D, figures 14-19

Shell of about usual size for the genus, subtriangular in outline; length and width about equal; beak forming about a right angle; sides somewhat narrowly rounded; anterior margin gently rounded. Surface costate, about 22 rounded, fairly strongly elevated costae with narrower interspaces; 4 costae occupy the sulcus, and 5 occur on the fold.

Pedicle valve equal to the brachial valve in depth, moderately convex in lateral profile and with the greatest convexity in the posterior half. Umbonal region narrowly swollen; sulcus originating about the middle, poorly defined. Flanks slightly convex, sloping steeply to the margins.

Brachial valve gently convex in lateral profile and with the maximum convexity located in the posterior half; umbonal and median regions somewhat swollen and anterolateral areas slightly less tumid. Fold scarcely visible, originating at about the middle and occupying less than half the width at the front. Flanks moderately convex with fairly steep slopes to the margins.

Measurements in mm.—Holotype, length 7.7, brachial length 6.7, width 7.5, thickness 5.3.

Types.—Holotype: 111284a; unfigured paratype; 111284b.

Horizon and locality.—Rock Levee formation in Missouri: Junction State

Highway 74 and U. S. Highway 61 at Rock Levee, $3\frac{1}{4}$ miles southwest of Cape Girardeau, NW. corner sec. 24, T. 30 N., R. 13 E., Cape Girardeau (15') Quadrangle.

Discussion.—This species may be recognized by its strong costae and by the slight development of the fold and sulcus, in which respect it differs from *A. crassa*.

ANCISTRORHYNCHA ? PERPLEXA Cooper, new species

Plate 127, C, figures 14-19

Shell small for the genus, subcircular in outline; apical angle about 115° ; sides narrowly rounded; anterior margin truncated. Anterior commissure strongly uniplicate. Surface costate, more strongly than usual in the genus, costae narrowly rounded with deep separating grooves; 4 costae on the fold, 3 in the sulcus, and 7 or 8 on the flanks.

Pedicle valve fairly strongly convex in lateral profile and with the greatest convexity at the middle; anterior profile moderately and broadly convex; umbo narrowly swollen; median region swollen; sulcus originating at about the middle, moderately deep, occupying slightly less than half the midwidth; tongue moderately long; flanks somewhat inflated and with moderately steep slopes. Beak long and strongly incurved.

Brachial valve slightly deeper than the pedicle valve, strongly convex in both profiles; umbo flattened and sulcate; sulcus short, shallow, and disappearing at the middle where the fold originates; fold short and low; flanks swollen and with steep lateral slopes.

Measurements in mm.—Holotype, length 6.0, brachial length 5.5, width 6.4, thickness 4.5.

Type.—Holotype: 111297.

Horizon and locality.—McLish formation in Oklahoma: In sec. 35, T. 1 S., R. 7 E., 1 mile southwest of McLish Ranch house, west of Bromide, Johnston County.

Discussion.—This species is characterized by its sharp and strong costae, the moderately deep sulcus, and sharply defined fold. These features, not usually seen in *Ancistrorhyncha*, distinguish it from all known species of the genus. A median septum was not observed in the brachial valve, the presence of which could relate the species to *Rostricellula* or allied forms. This species is therefore tentatively placed in *Ancistrorhyncha*.

ANCISTRORHYNCHA ? VACUA Cooper, new species

Plate 128, C, figures 10-13

Shell small, subtriangular to subpentagonal in outline. Posterolateral margins straight forming an angle of 90° at the beak. Sides narrowly rounded and with the greatest shell width located slightly anterior to the middle. Anterior margin broadly rounded. Anterior and lateral margins faintly costate, posterior half (?)

smooth. Sulcus occupied by 2 or 3 costae, and 3 or 4 occur on the brachial fold. The flanks are marked by 2 or 3 costae.

Pedicle valve in lateral profile fairly strongly convex in the posterior half but somewhat flattened in the anterior portion. Anterior profile moderately convex with a slight depression at the middle in some specimens. Sulcus short, wide, and shallow, producing a short, broadly rounded tongue. Areas bounding sulcus moderately convex, while the flanks of the shell are moderately convex and with steep lateral slopes.

Brachial valve strongly convex in lateral profile with the maximum convexity slightly posterior to the middle. Anterior profile moderately convex. Fold low and not prominent, defined at the anterior only. Body of shell slightly swollen and with steep lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 4.8 | 4.3 | 5.0 | 2.9 |
| Paratype (III282b) | 4.8 | 4.3 | 5.4 | 3.2 |
| " (III282c) | 4.5 | 3.9 | 4.2 | 2.8 |

Types.—Holotype: III282a; unfigured paratypes: III282b,c.

Horizon and locality.—Mingan formation (zone A5) in Quebec, Canada: Mingan (or Bald Island), Mingan Islands, St. Lawrence River.

Discussion.—These little shells combine some of the exterior features of *Ancistrorhyncha* and *Camerella*. The costation is like that of *Camerella* in its shortness and strength. Most other species of *Ancistrorhyncha* are completely costate and the costae are generally finer and more numerous. The folding of this little species is, nevertheless, like that of *Ancistrorhyncha*. The determining factor for placing the species in *Ancistrorhyncha* is its internal structure—or in this case, lack of internal structure. The shells are filled with crystalline calcite, a fact that makes determination of the interior details very difficult. Twenhofel (Twenhofel and Whiting, 1938, p. 54) assigned specimens from the same place and horizon to *Rhynchocamara varians* and regarded them as the young of that species. Twenhofel stated that the specimens had been entirely replaced by crystalline calcite. This is not true; the shells have been filled but not replaced by the mineral because the fibrous nature of the shell is still retained.

In order to study these specimens, they were immersed in water and examined in a strong light. By this method a certain translucency of the outer shell was obtained. If these specimens belonged to the genus *Rhynchocamara*, the strong median septum of both valves would have been visible. The brachial valve revealed no trace of septa which would have been clearly visible in the few shells filled by opaque calcite. The pedicle valves showed short dental plates. This combination of characters in the pedicle valve and lack of septa in the brachial valve in connection with the *Ancistrorhyncha*-like external expression led to the placing of the species in that genus.

This species differs from all those herein described by its naked umbos, strong costae, and general resemblance to *Camerella*.

DREPANORHYNCHA Cooper, new genus(Greek *drepanon*, sickle; *rhynchus*, beak)

Shell rhynchonelloid in outline and profile; hinge narrow, both valves provided with narrow interareas; delthyrium open; anterior commissure uniplicate; surface costate; shell fibrous, impunctate.

Pedicle valve with deep delthyrial cavity bounded by slightly convergent dental plates; teeth large; musculature indistinct. Brachial valve with deep sockets, divided hinge plate with concave outer hinge plates, long crural bases, and long, slender, curved crura. Crural bases united with posterior of notothyrial cavity and lying obliquely under the notothyrial edge. Median septum lacking.

Genotype.—*Porambonites ottawaensis* Billings = *Drepanorhyncha ottawaensis* (Billings), Paleozoic fossils, vol. 1, p. 140, fig. 117 (adv. sheets), 1862.

Discussion.—This species was at first mistakenly placed under the genus *Porambonites* with which it has nothing in common externally or in the interior. Later it was transferred to *Camerella*, but it is no more at home in that niche than it is in the first category. Later Schuchert and Cooper, 1932 (plate 16) transferred *P. ottawaensis* to *Orthorhynchula* because it possessed a pedicle interarea and a divided hinge plate with concave crural supports. Reexamination of the types of *P. ottawaensis* and additional material, together with study of better interiors of *Orthorhynchula*, show that the two types have little in common besides the interareas.

Drepanorhyncha is characterized by the presence in the pedicle valve of elongate dental plates spaced fairly closely together making a deep and narrow delthyrial chamber. The muscles are separated by a low and narrow median ridge. In the brachial valve the plates bearing the crura are concave and are supported by attachment to the posterior of the notothyrial cavity and the edge of the notothyrial margin facing the brachial valve. The crura are exceptionally long and slender. No median septum nor cardinal process is present.

In contrast to *Drepanorhyncha* the dental plates of *Orthorhynchula* are short and receding and are attached closely to the lateral walls of the valve. In the brachial valve the hinge plate is divided into two concave outer hinge plates which are concave and resemble those of *Drepanorhyncha* although they lie in the valve differently, presenting the concave face toward the pedicle valve, whereas in *Drepanorhyncha* the same plates lie obliquely facing each other. In *Orthorhynchula*, furthermore, the hinge plates are attached to a median swelling that bears a typical orthoid cardinal process situated between the two plates. The cardinal process has a stout shaft and a compressed and crenulated myophore like that of *Hebertella*. The median ridge, although low, is present and prominent.

As far as known the genus *Drepanorhyncha* occurs only in Trenton rocks in New York and Ontario.

DREPANORHYNCHA AMBIGUA (Hall)

Plate 128, G, figures 37-39

Atrypa ambigua HALL, Pal. New York, vol. 1, p. 143, pl. 33, figs. 8, 9, 1847.—EMMONS, Amer. geology, vol. 1, pt. 2, p. 190, pl. 10, figs. 8, 8c, 9, 1855.

Triplexia ? *ambigua* HALL, 12th Rep. New York State Cab. Nat. Hist., p. 65, 1859.

Camarella ambigua MILLER, Amer. Paleozoic fossils, p. 107, 1877.

This species has long been difficult to place. The closely spaced and fairly long dental plates of the pedicle valve preclude placing the species in *Camerella*, and the lack of the forked cardinal process of the brachial valve excludes it from *Triplexia*. The brachial valve shows the same type of hinge plate as that of *Drepanorhyncha*, and the plates are attached at the posterior of the notothyrial cavity, the sutures showing as two short lines on the umbo of the brachial valve.

Types.—Figured hypotypes: 111344a,b.

Horizon and locality.—Hull formation in New York: At Trenton Falls, Russia, and Middleville.

DREPANORHYNCHA OTTAWAENSIS (Billings)

Plate 128, E, figures 20-31

Porambonites ? *ottawaensis* BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 140, fig. 117 (adv. sheets, 1862), 1865.—MILLER, North American geology and paleontology, p. 362, fig. 598, 1889.

Rhynchotrema ottawaensis (Billings) SCHUCHERT, U. S. Geol. Surv. Bull. 87, p. 369, 1897.

Orthorhynchula ottawaensis (Billings) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 42, pl. 16, figs. 6, 9, 13, 1932.

Rhynchotrema ? *ottawaensis* (Billings) WILSON, Geol. Surv. Canada, Bull. 8, p. 121, pl. 11, figs. 9-11, 1946.

Horizon and locality.—Rockland formation in Canada: At Paquette Rapids, Ottawa River, Ontario.

Types.—Lectotype: G.S.C. 1143g; paratypes: G.S.C. 1143?, 1143e,h; figured hypotypes: 85338a,b.

Family RHYNCHOTREMATIDAE Cooper, new family

Rhynchonellacea with rudimentary deltidial plates and well-formed dental plates in the pedicle valve; brachial valve provided with a small cruralium, with or without a cardinal process, long crural processes. Cruralium without covering plates as in *Camarotoechia*.

Genus RHYNCHOTREMA Hall, 1860

Plate 138, A, figures 1-7

Rhynchotrema HALL, 13th Rep. New York State Cab. Nat. Hist., p. 68, 1860.—WANG, Geol. Soc. Amer. Mem. 42, p. 11, 1949.

For many years this genus has been misunderstood. The only species name used with the genus when Hall first proposed the name was *increbescens*. Wang (1949, p. 11) points out that this species thus becomes the type of the genus. Under the heading *Rhynchonella increbescens* Hall defined the characters of *Rhynchotrema* from specimens taken at Iron Mountain, Wis., specimens that are now assigned to *Lepidocyclus capax*. In spite of this inconsistency the genus rests on *R. increbescens*. Wang finally fixed the type of *R. increbescens* as the

specimen figured by Hall (Pal. New York, vol. 1, pl. 33, fig. 13c-d). Through the kindness of the American Museum of Natural History and Dr. N. D. Newell, the writer was permitted to examine this specimen.

The type lot of *R. increbescens* consists of four specimens. Two of them, figures a,b and c,d, on plate 33, figure 13, are similar and probably were derived from the same bed. The third specimen, represented by figures e,f, is black in color, is wider and thicker, and is probably from a different part of the Trenton limestone. The last specimen is even larger than the third and has a strongly incurved beak and considerably swollen brachial valve. It seems quite different from the others.

The type specimen selected by Wang is small; length 11.1 mm., width 12.2 mm., and thickness 8.2 mm. None of the original shell remains on this specimen, but Hall (Pal. New York, vol. 1, p. 147, 1847) implies that it was marked by "flexuous imbricating striae." The sulcus is marked by 3 costae, the fold by 4, and the flanks by 6 or 7. Unfortunately, the fact that the specimen is essentially a cast of the interior makes it impossible to determine any of the important beak characters, but it does permit description of some of the interior details. The pedicle valve had a moderately deep delthyrial cavity defined by short, delicate dental plates. No trace of the musculature appears on the cast.

The interior of the brachial valve was provided with a median septum reaching to about the middle and supporting a small cruralium. The hinge plate is divided with the halves somewhat concave but their shape not determinable. Muscle marks are not determinable. On the filling of the cruralium a short, thin white line indicates the presence of a small cardinal process. The latter feature does not appear on the second specimen which is similar to the lectotype.

This type of interior is characteristic of several species of the middle part of the Trenton. Along with this interior goes an imbricate ornamentation and beak characters that set *Rhynchotrema* off from Wang's genus *Lepidocyclus*.

The generic characters of *Rhynchotrema* are here defined as follows: triangular, costate, rostrate shells usually with lamellose ornamentation; pedicle valve with delthyrium partially closed by narrow, elongate deltidial plates on the sides; beak often resorbed by pedicle pressure to form a small, round foramen; dental plates short; teeth thick and stout, with large fossettes.

Muscle field triangular with diductor scars enclosing the adductors; adductor scar somewhat heart-shaped, large. Brachial interior with divided hinge plate; sockets deep; socket ridge narrow; hinge plate gently concave, subtriangular; crura curved, moderately long; cardinal process slender to thick, often filling the cruralium; median septum extending to the middle.

RHYNCHOTREMA KENTUCKIENSE Fenton and Fenton

Plate 130, A, figures 1-8

Rhynchotrema kentuckiense FENTON and FENTON, Proc. Iowa Acad. Sci. for 1922, vol. 29, p. 67, pl. 1, figs. 4, 5; 18-22, 1924.

Rhynchotrema inaequivalvis Castelnau, WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, pl. 34, figs. 24, 25, 1895.

Types.—Figured hypotypes: 117211a-c.

Horizon and locality.—Trenton formation in Kentucky: Danville, Boyle County; Burgin, Mercer County; Paris, Bourbon County; and Curdsville, Daviess County.

RHYNCHOTREMA WISCONSINENSE Fenton and Fenton

Plate 128, H, figures 40-48; plate 138, G, figures 43-45

Rhynchotrema wisconsinense FENTON and FENTON, Proc. Iowa Acad. Sci. for 1922, vol. 29, p. 71, pl. 1, figs. 6-8, 1924.

Rhynchotrema inaequivalvis Castelnau (part), WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, pl. 34, figs. 13, 14, 1895.

Types.—Figured hypotypes: 24843a,b, 117210a.

Horizon and locality.—Decorah formation (Ion member) in Minnesota and Wisconsin.

Genus ROSTRICELLULA Ulrich and Cooper, 1942

Rostricellula ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 625, 1942.

Shell rhynchonelliform, generally subtriangular to subpentagonal in outline, more rarely transversely elliptical. Anterior commissure uniplicate. Pedicle valve with pointed and generally incurved beak; delthyrium open or partially restricted by rudimentary deltidial plates. Interarea narrow, almost obsolete. Pedicle interior with strong dental plates separated from the sides of the valve by narrow umbonal cavities. Teeth small, curved. Delthyrial cavity deep, occupied wholly by the scar of the pedicle attachment; muscle field situated anterior to the delthyrial cavity, like *Rhynchotrema* in pattern.

Brachial interior with divided hinge plate united to median septum by short supporting plates that form a small chamber or cruralium beneath the beak. Brachial processes long and slender, curved. Median septum strong, elevated, reaching to middle of valve or beyond. Adductor impressions located on each side of the septum in the posterior half of the shell. Cardinal process absent.

Genotype.—*Rostricellula rostrata* Ulrich and Cooper, new species. Journ. Paleont., vol. 16, No. 5, p. 626, pl. 90, figs. 24, 28, 29, 32, 37, 1942.

Discussion.—This genus differs from *Rhynchotrema* by absence of a cardinal process in the brachial valve and nonimbricate ornamentation.

ROSTRICELLULA ACUTIPPLICATA Cooper, new species

Plate 133, F, figures 36-41; plate 138, D, figures 25-38

Shell of about medium size for the genus, wider than long with a somewhat rectangular outline in the old adult but triangular in young adults. Apical angle about 105°. Sides rounded; anterior margin truncated. Widest slightly anterior to the middle. Fold marked by 3 to 5 costae, the sulcus by 2 to 4, and the flanks by 7 to 9. Surface finely filate and papillose.

Pedicle valve with nearly flat lateral profile in which the umbonal region is slightly inflated; anterior profile very gently convex. Sulcus originating 4 to 6 mm. anterior to the beak. Sulcus deep at the front; tongue long and narrow. Flanks flattened and gently sloping to the margins.

Brachial valve fairly evenly convex in lateral profile but the convexity gentle and most marked on the fold; anterior profile moderately strongly arched. Umbonal region swollen but medially sulcate for a short distance; fold narrow and high, especially at the front end. Costation of fold variable, costae often appearing on sides of fold. Flanks well rounded and steeply sloping to the margins.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 13.4 | 12.2 | 16.0 | 9.0 |
| Paratype (117212b) | 10.7 | 9.5 | 13.6 | 7.1 |
| " (117213a) | 13.5 | 12.2 | 17.0 | 15.2 |
| " (117212d) | 11.5 | 10.4 | 13.0 | 6.9 |

Types.—Holotype: 117212a; figured paratypes: 117212b,d, 117213a,b; unfigured paratype: 117212c.

Horizon and locality.—Prosser formation (*Zygospira bed*) in Minnesota: At St. Anthony's Hill, St. Paul; Kenyon, Goodhue County; Cannon Falls, Goodhue County; and Warsaw, Rice County.

Discussion.—This species may be recognized by its fairly narrow and fairly strongly elevated fold, erect beak, and depressed flanks of the brachial valve. This combination of features is quite unlike those of any other species described herein. The species somewhat resembles *R. pulchra*, but that species has a wider and lower fold and the flanks are not depressed.

ROSTRICELLULA AINSLIEI (N. H. Winchell)

Plate 135, A, figures 1-7; plate 138, E, figure 39

Rhynchonella ainsliei N. H. WINCHELL, 14th Ann. Rep. Geol. Nat. Hist. Minnesota, p. 315, pl. 2, figs. 5, 6, 1886.

Rhynchotrema ainsliei (Winchell) WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 459, pl. 34, figs. 1-8, 1895.

A specimen of the brachial valve shows the typical cardinalia of *Rostricellula* having very long brachial processes and no cardinal process. The exterior is marked by fine, crowded, concentric lines of fine pustules.

This species is characterized by its transverse form, evenness of its costae, and the well-rounded lateral margins. In these respects it differs from other described species except *R. rotunda*. From that species it differs in its larger size and proportions.

Measurements in mm.—Hypotype (24866a), length 13.5, brachial length 12.5, width 18.0, thickness 10.3.

Types.—Figured hypotypes: 24866a, 48943a.

Horizon and locality.—Decorah formation (Spechts Ferry member—*Stictoporella bed*), Minneapolis, west St. Paul, Minnesota. Decorah formation, Chatfield, Fillmore County; Fountain, Fillmore County; Elmira, Olmstead County.

ROSTRICELLULA ? ANGULATA Cooper, new species

Plate 134, D, figures 33-46

Slightly wider than long, triangular in outline, apical angle slightly less than 90° . Posterolateral margins straight; anterolateral extremities narrowly rounded; anterior margin broadly rounded. Costate, 3 costae on the fold, 2 in the sulcus, and 6 to 8 on the flanks.

Pedicle valve gently convex in lateral profile, broadly and gently concave in anterior profile; sulcus originating at about the middle, deepening rapidly. Tongue moderately long. Anterolateral extremities prominently elevated above the sulcus. Flanks flattened but with steep slopes.

Brachial valve deeper than the pedicle valve and with low convexity in lateral view, most convex in the umbonal region but flattened anteriorly. Anterior profile broadly and gently convex. Umbo sulcate; fold originating about 4 mm. anterior to the beak; fold flattened in both profiles, elevated strongly only at the anterior end. Flanks gently rounded and with moderate slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 12.7 | 12.0 | 14.5 | 7.1 |
| Paratype (117214b) | 14.0 | 13.0 | 14.2 | 8.6 |
| " (117214c) | 12.5 | 11.2 | 12.4 | 8.0 |

Types.—Holotype: 117214a; figured paratype: 117214b; unfigured paratype: 117214c.

Horizon and locality.—Lower part of dark gray shale in Eureka group, in Nevada: On the north-facing nose of hill 8167 on Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by distant, strong, angular costae and by the presence of only 2 costae in the sulcus. This species differs from *R. truncata*, the only other one like it, in having only 2 costae in the sulcus, in having 5 or 6 costae on the flanks rather than 4, and in having a narrower apical angle and a narrower fold.

ROSTRICELLULA BASALARIS Cooper, new species

Plate 132, E, figures 21-29; plate 132, F, figures 30-37; plate 137, C, figures 20-26; plate 137, D, figures 27-33; plate 137, F, figures 37-46

Rostricellula pristina COOPER and COOPER (not Raymond), Bull. Geol. Soc. Amer., vol. 57, p. 112, pl. 2, figs. 16, 17, 1946.

Shell of about medium size, triangular in outline, length and width about equal; apical angle slightly less than 90° . Fold marked by 3 or 4 costae, the sulcus by 2 or 3, and the flanks by 5 or 6.

Pedicle valve slightly less deep than the brachial valve, gently convex in lateral and anterior profiles; sulcus originating 2 to 3 mm. anterior to the beak, deepening anteriorly and occupying about half the width at the front, tongue moderately long. Costae bounding sulcus strongly elevated at anterior end; flanks flattened and moderately steep.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 8.8 | 8.1 | 9.3 | 5.4 |
| Paratype (111520a) | 8.2 | 7.4 | 8.7 | 6.6 |
| “ (118036) | 9.4 | 8.5 | 8.5 | 5.9 |

Types.—Holotype: 111520b; figured paratypes: 111458a,b, 111520a, 111524a-c, 111793a-c, 118036; unfigured paratypes: 111520c,d.

Horizon and locality.—Lower Lenoir formation in Tennessee: East of U. S. Highway 11 about $\frac{1}{8}$ mile south of the hosiery mill in Lenoir City, Lenoir City (T.V.A. 130-SE) Quadrangle; south bank Southern RR., $1\frac{1}{2}$ miles southwest of Philadelphia, Philadelphia (T.V.A. 130-NW) Quadrangle; 3 miles northeast of Athens, Athens (T.V.A. 125-NE) Quadrangle; just above the Knox in the calcarenites behind the Friends Church, Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 50 feet above the Mosheim formation at Marble Bluff, 8 miles west-northwest of Loudon, Loudon (30') Quadrangle.

Mosheim formation in Tennessee: $\frac{1}{2}$ mile east of the railroad station just east of Morristown, Morristown (T.V.A. 163-NE) Quadrangle.

Tumbez formation (part) in Virginia: On Virginia Highway 80, 0.8 mile north of Geisler Mill, Glade Spring (T.V.A. 212-SE) Quadrangle; in Moccasin Creek along Virginia Highway 679, $\frac{3}{4}$ mile south of Tumbez, Moll Creek (T.V.A. 196-SE) Quadrangle; Staunton Lime Quarry, $\frac{1}{2}$ to $\frac{3}{4}$ mile north of Virginia Highway 250, 2 miles east of Staunton, Staunton (15') Quadrangle.

Mosheim formation in Alabama: $\frac{1}{4}$ to $\frac{1}{2}$ mile southwest of Newhope Church, Vandiver (15') Quadrangle.

Lenoir formation in Alabama: 2 to 3 miles south of Pelham, Bessemer Iron District (15') Quadrangle.

Row Park formation in Maryland: On the Duffy Farm, 0.6 miles west of Hicksville and 0.8 mile south-southwest of Fairview, Williamsport (15') Quadrangle.

Discussion.—For some years this species has been referred to *R. pristina* Raymond, but it is a quite different species. *Rostricellula basalaris* occurs in many places at the base of the Lenoir limestone. It is a lover of calcarenites and somewhat silty limestone. The species is characterized by a distinctly triangular outline, a small apical angle, the midwidth anterior to the middle, and a variable number of costae in the sulcus. The New York Chazy species is more rounded laterally and with the maximum midwidth at about the middle. Furthermore, its apical angle is greater than that of the Southern Appalachians species.

Rostricellula basalaris shows considerable variability from place to place, some of it due to preservation. Specimens from the Mosheim limestone in Alabama are often somewhat distorted, as are specimens from Staunton, Va. The distortion may somewhat thicken the shells if the pressure has been directed parallel to the long axis.

ROSTRICELLULA COLEI Cooper, new species

Plate 138, C, figures 10-24

Shell large for the genus, wider than long with the greatest width at or near the middle; sides rounded; anterior margin gently convex. Apical angle 105° . Sulcus marked by 3 to 5 costae, fold by 4 to 6, and the flanks by 9 to 10.

Pedicle valve moderately convex in lateral profile with the most curvature at the umbo; anterior profile gently concave in the median region. Sulcus originating about 7 mm. anterior to the beak. Sulcus narrow and moderately deep, forming somewhat less than half the width. Tongue moderately long and narrow, somewhat pointed. Flanks flattened, moderately steep.

Brachial valve deeper than the pedicle valve, fairly strongly convex in lateral profile; anterior profile varying from moderately to strongly arched. Fold originating just posterior to the middle, low posteriorly but fairly strongly elevated anteriorly; fold generally narrow and composed of a varying number of costae; median costae of fold often more prominent than lateral ones which may be located on sides of fold. Flanks inflated and rounded, steep.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 14.4 | 12.7 | 15.9 | 12.6 |
| Paratype (117216a) | 13.6 | 12.3 | 16.0 | 10.0 |
| " (117216b) | 15.0 | 13.8 | 16.4 | 11.7 |
| " (117216c) | 16.2 | 14.4 | 17.9 | 13.5 |
| " (117216e) | 16.7 | 15.1 | 18.8 | 15.1 |
| " (117216f) | 14.0 | 12.7 | 15.0 | 11.7 |

Types.—Holotype: 117216d; figured paratypes: 117216a,e; unfigured paratypes: 117216b,c,f.

Horizon and locality.—Decorah formation (upper part of Ion member) in Goodhue County, Minn.: From a road cut on the county road 1.1 miles east of U. S. Highway 52 in the south edge of Cannon Falls; Kenyon. On U. S. Highway 52, 1 mile south of Fountain, Fillmore County.

Same formation in Iowa: West of Decorah, Winneshiek County.

Discussion.—*Rostricellula colei* can be recognized by its large size and swollen valves. It thus contrasts strongly with *Rhynchotrema wisconsinense* with which it occurs. It is further distinguished by a fairly narrow and moderately well elevated fold for such a large shell. It resembles *R. minnesotensis* in its robust form but has a narrow fold and more tumid valves besides being a much larger species.

ROSTRICELLULA COMPRESSA Cooper, new species

Plate 133, B, figure 12; plate 134, A, figures 1-18

Shell of about medium size for the genus, triangular in outline with the greatest width located near the anterior margin. Beak acute, sides nearly straight to the anterolateral extremities where they are narrowly rounded; anterior margin abruptly truncated. Costae numbering 15 to 17, 3 or 4 on the fold, 2 on the flanks and 4 or 5 on the flattened slope between the flanks and the margins; 2

or 3 costae occurring in the sulcus. Fine ornamentation consisting of irregular concentric fila.

Pedicle valve very gently convex in lateral profile with the greatest convexity between the beak and the middle. Umbonal region and posterior third gently convex; sulcus originating 7 to 8 mm. anterior to the beak, widening and deepening rapidly to occupy slightly more than half the valve width. Tongue long, truncated anteriorly, and in old shells somewhat flattened to form a broad base. Flanks narrowly rounded with strongly pointed anterolateral extremities. Slope to margins nearly flat and nearly vertical to the commissure, and marked by 4 or 5 obscure costae. Beak incurved; delthyrium open.

Brachial valve gently convex in lateral profile and with the greatest convexity located at about the middle; anterior profile with a flattened top and nearly vertical sides. Fold originating at 4 to 5 mm. from the beak, scarcely perceptible near the middle of the valve and becoming more elevated anteriorly but never strongly set off from the body of the valve. Two median costae of sulcus often slightly depressed below the bounding costae. Flanks narrowly rounded with the anterolateral extremities elongated in the direction of the pedicle valve and, with the fold, forming a deep reentrant that accommodates the tongue of the pedicle valve. Sides steep and nearly vertical to the commissure. Umbo sulcate.

Interior: Teeth small, dental plates well developed but short and confined to the sides of the valve, forming narrow slitlike umbonal cavities. Delthyrial cavity occupied by pedicle callist; muscle field located anterior to callist and dental plates; adductor scar small, oval, located in the posteromedian position next to the callist. Diductor scars large, flabellate, and surrounding other scars. Accessory diductors located in front of and on each side of the adductor scar.

Hinge plate divided, the halves supported by short plates attached to their under side and to the median septum to form a narrow chamber; outer side of hinge plates attached to side of valve by well-defined fulcral plates. Socket plates stout; outer hinge plates triangular, gently concave, giving off long slender crura from their inner side.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|------------------------|--------|-----------------|-------|-----------|
| Holotype | 12.7 | 11.4 | 11.9 | 8.6 |
| Paratype (III468)..... | 12.1 | 10.9 | 11.0 | 9.9 |
| “ (III481c)..... | 6.9 | 5.1 | 5.9 | 3.5 |
| “ (III480a)..... | 13.7 | 12.3 | 13.3 | 10.0 |

Types.—Holotype: III481a; figured paratypes: III462a-c, III468, III481c; unfigured paratypes: III480a,b, III481b,d.

Horizon and locality.—Lebanon formation in Rutherford County, Tenn.: On U. S. Highway 41, $\frac{3}{4}$ mile south of Knox Branch, about 9 miles southeast of Murfreesboro; 3 miles east and 3 miles northeast of Murfreesboro; cut and quarry on U. S. Highway 41, 12 miles southeast of Murfreesboro; Mount Olivet, 10 miles southeast of Murfreesboro on U. S. Highway 41; U. S. Highway 241, $1\frac{1}{2}$ miles (airline) southwest of Christiana. In Bedford County, Tenn.:

Tennessee Highway 16, 3.6 and 5.1 miles northwest of Shelbyville; 3 miles southwest of Woodbury. In Sequatchie Valley, Bledsoe County, Tenn.: Cedar Ridge, 1 mile southeast of Litton, Sequatchie Valley, Pikeville Special (15') Quadrangle. In Smith County, Tenn.: At the east end of the bridge on U. S. Highway 70N over Round Lick Creek at Rome. In Maury County, Tenn.: At Columbia.

Camp Nelson formation in Kentucky: At 140 to 150 feet, High Bridge, Harrodsburg (30') Quadrangle.

ROSTRICELLULA COSTATA Cooper, new species

Plate 130, B, figures 9-17

Camarotoecchia plena ? BUTTS, Alabama Geol. Surv., Special Rep. 14, pl. 22, figs. 4, 5, 1926.

Shell small for the genus, triangular to subpentagonal in outline; valves subequal in depth; beak slightly obtuse; sides nearly straight to slightly rounded; anterolateral extremities narrowly rounded and forming location of greatest width; front margin truncated. Surface costate, 3 costae generally occupying the sulcus, 4 on the fold, and 6 on the flanks.

Pedicle valve moderately convex in lateral profile with the greatest convexity located in the umbonal region; posterior half very gently convex; sulcus originating about 3 mm. anterior to the beak, broad and shallow, occupying about two-thirds the width at the front; tongue short, narrowly rounded toward the brachial valve, serrate but square in front. Sulcus bounded on each side by a strongly elevated angular costa higher than the costae of the sulcus and the flanks, which are narrow and steep-sided.

Brachial valve moderately convex in lateral profile with the greatest curvature located in the anterior part. Posterior half sulcate with the sulcus broad and shallow and bounded by narrowly rounded flanks. At about the middle, 2½ mm. from the beak of the brachial valve a fold develops out of the posterior sulcus in the form of 2 depressed costae flanked by a costa strongly elevated above those of the fold and the flanks on each side. Slopes to margins nearly vertical and flat-sided; flanks bounding sulcus narrowly rounded.

Interior: A single specimen shows a well-developed muscle field in the pedicle valve located anterior to the short dental plates. The field is trapezoidal in outline with a straight front margin. Individual scars not distinguishable.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|------------------------|--------|-----------------|-------|-----------|
| Holotype | 5.2 | 4.9 | 5.6 | 4.2 |
| Paratype (71486) | 6.0 | 5.5 | 5.9 | 5.0 |
| " (111460b) | 6.0+ | 5.9 | 6.6 | 4.0 |

Types.—Holotype: 111460a; unfigured paratype: 111460b; measured paratype: 71486.

Horizon and locality.—Lenoir formation in Alabama: 2 miles west-southwest of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This is a small species distinguished by the pronounced sulcate brachial umbo and the depression of the median 2 costae below the level of the outer 2 in the fold. The species may be related to *R. pristina* but is generally smaller and proportionately more convex. It differs from *R. orientalis*, which is a small shell, in the nature of the folding and the more compact outline and profile.

ROSTRICELLULA CUNEATA Cooper, new species

Plate 124, H, figures 44, 45

Shell small for the genus, cuneate, longer than wide; beak acute; sides nearly straight, divergent; anterior truncated. Surface marked by 11 narrowly rounded and elevated costae.

Pedicle valve gently convex in lateral profile except for the front which is narrowly rounded; anterior profile moderately broadly rounded. Umbonal region narrowly rounded; median region somewhat carinated by the prominent median costa. Median 3 or 5 costae elevated slightly in the anterior half to form a low fold; sides rounded and steep. Dental plates long and slightly curved.

Brachial valve gently convex in lateral profile except for the front marginal region which is narrowly curved toward the pedicle valve; anterior profile flattened to concave medianly but with narrowly rounded sides. Sulcus originating at the umbo and extending to the anterior margin. Median 2 to 4 costae bounding median sulcus depressed below the flanks to form a broad sulcate zone; flanks narrowly rounded and with nearly vertical sides, marked by 3 to 4 costae. Median septum long.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Widest part | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 4.0 | 3.7 | 3.0 | 3.4 | 2.1 |
| Paratype (117218b) | 3.7 | 3.2 | 2.5 | 3.1 | 1.8 |
| " (117218c) | 4.8 | ? | 3.1 | 4.0 | 1.5 |

Types.—Holotype: 117218a; unfigured paratypes: 117218b-d.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: West side U. S. Highway 77, sec. 25, T. 2 S., R. 1 E., 2 to 3 miles north of Springer, Carter County.

Discussion.—This species strongly resembles members of the genera *Sphenotreta* and *Dorytreta*, but the presence of the thick median septum in the brachial valve indicates affinities with *Rostricellula*. This species suggests young specimens of *R. costata*, but in that species the brachial valve is less sulcate than *R. cuneata*.

ROSTRICELLULA CUNEIFORMIS (Fenton and Fenton)

Plate 136, A, figures 1-22

Rhynchotrema cuneiformis FENTON and FENTON, Proc. Iowa Acad. Sci. for 1922, vol. 29, p. 72, pl. 1, figs. 12-14, 1924.

Silicified specimens of this species show the interior to perfection. In the pedicle valve the deep delthyrial cavity is occupied by a thickened pedicle callist

and the muscle area is located in front of it. The adductor field is deeply impressed. Inside the brachial valve the median septum is high and strong and supports a small cruralium, but a cardinal process is absent as usual for the genus. The brachial processes are long and curved.

Types.—Figured hypotypes: 111484a,d,e,g,o-r,t,u.

Horizon and locality.—Barnhart formation (or Macy) in Missouri: Along the old road 1 mile northwest of the Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E., Weingarten (15') Quadrangle; on the Fredericktown road, 5 miles southwest of Ste. Genevieve, Weingarten (15') Quadrangle; 0.2 mile south of Koch Valley School on U. S. Highway 67, Kimmswick (15') Quadrangle.

ROSTRICELLULA DECORAHENSIS (Fenton and Fenton)

Rhynchotrema decorahense FENTON and FENTON, Proc. Iowa Acad. Sci. for 1922, vol. 29, p. 72, pl. 1, figs. 9-11, 1924.

Types.—Univ. Chicago.

Horizon and locality.—Decorah formation in Iowa.

ROSTRICELLULA ELLIPTICA Cooper, new species

Plate 132, A, figures 1-5

Shells somewhat below medium size, elliptical in outline, sides narrowly rounded; the midwidth forming the widest part; apical angle about 100°; anterior margin nearly straight. Sulcus with 4 or 5 costae, fold with 5 or 6 costae, and the flanks marked by about 8 costae. Costae of fold and sulcus more widely spaced than those of the flanks.

Pedicle valve moderately convex in lateral profile and with the maximum curvature just anterior to the umbo; anterior profile fairly strongly convex; sulcus originating at about the middle; umbo somewhat swollen. Sulcus moderately deep anteriorly, its width equal to about half the valve width. Flanks moderately swollen and steep. Beak short and strongly incurved.

Brachial valve about equal to the pedicle valve in depth, moderately strongly convex, more so than the pedicle valve in lateral profile; anterior profile strongly convex and with steep sides. Fold originating near the middle, low throughout its extent. Flanks strongly swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 5.2 | 4.8 | 6.8 | 3.5 |
| Paratype (117217b) | 7.0 | 6.1 | 7.6 | 4.9 |
| " (117217d) | ? | ? | 10.0 | ? |
| " (117217e) | 5.6 | 5.0 | 6.7 | 3.2 |

Types.—Holotype: 117217a; figured paratypes: 117217b-d; unfigured paratype: 117217e.

Horizon and locality.—New Market formation in Virginia: From a quarry

$\frac{1}{2}$ mile west of U. S. Highway 11, on the north bank of Middle River, Staunton (15') Quadrangle.

Discussion.—This is a small species, represented by specimens of poor preservation. The specimens indicate a species so at variance with *R. basalaris* that a different specific name was thought to be warranted. The species is characterized by soft, rounded outlines and elliptical form with numerous costae marking the fold, sulcus, and flanks. It resembles *R. multicostata* but differs in size, less elongate outline, and somewhat wider fold. *Rostricellula basalaris* is more triangular and has more distant and coarser costae and is not likely to be confused with *R. elliptica*.

ROSTRICELLULA MAJOR (Raymond)

Plate 130, H, figures 38-42

Camarotoecchia major RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 369, 1905; Ann. Carnegie Mus., vol. 7, No. 2, p. 226, pl. 34, figs. 11-14, 1911.

Type.—Holotype: Carnegie Mus. 2171.

Horizon and locality.—Valcour formation in New York: At Cystid Point, Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Same formation in Vermont: From a small peninsula off the west shore of Providence Island, Plattsburg (15') Quadrangle.

ROSTRICELLULA MINNESOTENSIS (Sardeson)

Plate 131, A, figures 1-7; plate 139, A, figures 1-11

Rhynchonella minnesotensis SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 333, pl. 4, figs. 21-23, 1892.

This species is characterized by fairly large size and solid, robust form. It has an apical angle of slightly more than 90° , rounded sides, and a truncated front. The fold has 4 costae, the sulcus 3 costae, and the flanks are marked by 6 or 7 costae.

The valves are of subequal depth and fairly deep; the profiles are moderately convex. The brachial umbo is sulcate, and the 2 median costae do not equal the elevation of the lateral costae until about the middle of the valve. The tongue of the pedicle valve is fairly long, but the fold of the brachial valve is low and flattened in profile.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|-----------------|-------|-----------|
| Hypotype (117219a)..... | 13.3 | 11.6 | 15.0 | 11.2 |
| " (117219b)..... | 12.0 | 10.6 | 12.9 | 8.3 |

Types.—Figured hypotypes: 117219a,b, 118035a.

Horizon and locality.—Platteville formation (McGregor member) in Wisconsin: On Highway 81, 1 mile northwest of Ellenboro, Lancaster (30') Quadrangle; Janesville and Beloit, Rock County; Mineral Point, Mineral Point (30') Quadrangle; Dodgeville, Iowa County.

Same formation in Minnesota: At Fountain, Fillmore County.

Same formation in Illinois: $1\frac{1}{2}$ miles northeast of Dixon, Lee County. Decorah formation (Spechts Ferry member) in Minnesota: On the road $\frac{1}{4}$ mile east of U. S. Highway 52 in the south edge of Cannon Falls, Goodhue County.

Discussion.—*Rostricellula minnesotensis* is best identified by its rotund and robust form, combined with swollen flanks and low, wide fold. The species suggests *R. colei* but differs in having a wider and lower fold. It is similar to *R. pulchra* but differs in its more robust and rotund form, more strongly costate flanks, and less strongly costate sulcus.

ROSTRICELLULA ? MINUTA Cooper, new species

Plate 137, A, figures 1-6

Shell small for the genus, elliptical in outline with the greatest width at about the middle. Sides narrowly rounded; anterior margin broadly rounded. Fold marked by 2 strong, angular costae; sulcus containing a single costa, and flanks marked by 7 or 8 costae.

Pedicle valve about equal in depth to the brachial valve, gently convex in lateral profile and with the greatest convexity at about the middle. Anterior profile moderately convex. Beak strongly incurved; umbo narrowly swollen. Sulcus originating about $1\frac{1}{2}$ mm. anterior to the beak, deep and occupying about half the width; costae bounding sulcus strongly elevated and forming a sort of fold bounding the sulcus. Flanks concave and with a steep slope to the margins. Tongue moderately long.

Brachial valve nearly flat in the median region when seen in lateral profile but with the umbonal and anterior regions narrowly convex; anterior profile gently convex but with the fold much elevated. Fold narrow and elevated particularly at the front end. Flanks moderately swollen.

Measurements in mm.—Holotype, length 5.3, brachial length 4.9, width 6.3, thickness 3.6.

Types.—Holotype: 117220a; figured paratype: 117220b.

Horizon and locality.—Hermitage formation in Tennessee: From 0.7 to 1.25 miles south-southeast of Woodbury, Woodbury (15') Quadrangle.

Discussion.—This species is characterized by its small size, the exceptionally deep sulcus, and high narrow fold. It is further characterized by having only a single costa in the sulcus. The exterior aspect of the species is unlike most known *Rostricellula*, but a cross section of the brachial beak indicates a structure normal for *Rostricellula*. The pedicle valve possesses moderately long dental plates and foraminal characters like *Rostricellula*. The interior features thus indicate relationship to *Rostricellula*. The exterior surface, however, deviates from *Rostricellula* as far as can be observed in lacking fine wavy lines or granules. The combination of specific characters in this species is unlike any others described herein.

ROSTRICELLULA MISSOURIENSIS (Fenton and Fenton)

Plate 135, B, figures 8-10

Rhynchotrema missouriense FENTON and FENTON, Proc. Iowa Acad. Sci. for 1922, vol. 29, p. 73, pl. 2, figs. 22-26, 1924.

Figured specimen.—III488.

Horizon and locality.—Barnhart (or Macy) formation in Weingarten (15') Quadrangle, Missouri: 2½ miles west of Ste. Genevieve; 1½ miles north of Chicago Summer School Camp.

ROSTRICELLULA MULTICOSTATA Cooper, new species

Plate 139, D, figures 37-53

Shell of about medium size for the genus, slightly wider than long; apical angle about 100°; sides narrowly rounded; anterior margin gently and broadly rounded. Costate, 4 to 8 costae in the sulcus, 5 to 9 on the fold, and 11 on the flanks.

Pedicle valve gently convex in lateral profile and with the greatest convexity at the umbo; anterior profile broadly and gently convex; sulcus originating 2 to 3 mm. anterior to the beak; sulcus broad and shallow throughout; tongue short, broadly rounded. Umbo strongly swollen; beak strongly curved and overhanging the brachial umbo. Flanks narrow, gently convex and with steep slopes.

Brachial valve fairly strongly convex in lateral profile and with the maximum convexity at the middle; anterior profile strongly and broadly convex; fold originating at or near the middle, low throughout its extent; umbonal and median regions inflated; flanks swollen and with steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 11.3 | 10.0 | 12.4 | 7.6 |
| Paratype (117221b) | 9.7 | 8.6 | 10.7 | 7.2 |
| “ (117221c) | 10.0 | 8.7 | 10.2 | 7.2 |
| “ (117221d) | 10.1 | 9.0 | 9.6 | 6.7 |
| “ (117221e) | 9.2 | 8.0 | 10.2 | 6.6 |
| “ (117221f) | 8.7 | 7.7 | 9.6 | 6.6 |
| “ (117221g) | 6.8 | 6.2 | 7.4 | 4.8 |
| “ (117221h) | 6.1 | 5.5 | 6.8 | 4.1 |

Types.—Holotype: 117221a; figured paratypes: 117221c,e; unfigured paratypes: 117221b,d,f-i.

Horizon and locality.—Ellett formation, calcarenite 10 feet above the Knox in Virginia: Slope on west side Virginia County Highway 615, 1 mile south of Ellett, Blacksburg (15') Quadrangle.

Discussion.—This species is suggestive of *R. plena* (Hall) but is uniformly smaller in size than that species and is a more rotund form. It differs from other species seen at the base of the Lenoir in its larger size and more numerous costae.

ROSTRICELLULA NUCLEOLATA Cooper, new species

Plate 135, D, figures 16-25

Shell small for the genus, somewhat globular, slightly wider than long. Posterolateral margins short and straight, sides moderately rounded; anterior margin broadly rounded. Apical angle slightly less than 100°. Costae elevated and narrowly rounded, numbering 4 on the fold, 3 in the sulcus, and 4 on the flanks.

Pedicle valve gently convex in lateral profile and nearly flat in anterior profile; umbonal region convex and somewhat swollen; sulcus broad and shallow, originating 5 mm. anterior to the beak which is strongly incurved. Tongue short, not strongly geniculated. Flanks narrowly rounded and steep.

Brachial valve slightly deeper than the pedicle valve, evenly and gently convex in lateral profile, broadly and flatly convex in anterior profile but with precipitous sides. Umbonal region gently sulcate; fold low, slightly elevated above the flanks at the anterior end. Flanks narrowly rounded and steep-sided.

Measurements in mm.—Holotype, length 9.3, brachial length 8.4, width 10.0, thickness 7.0.

Types.—Holotype: 48984a; unfigured paratypes: 48984 (unlettered).

Horizon and locality.—Platteville formation (lower buff = Pecatonica member) in Minnesota: At Minneapolis.

Discussion.—Small size and rotund form characterize this species. Its nearest relative is *R. minnesotensis* from which it differs in size, rotundity, and a wider fold and sulcus.

ROSTRICELLULA ORIENTALIS (Billings)

Plate 129, G, figures 26-32; plate 135, C, figures 11-15; plate 137, I, figures 61-65

Rhynchonella orientalis BILLINGS, Canadian Nat., vol. 4, p. 443, fig. 21, 1859.—LOGAN, Geol. Canada, p. 126, fig. 57, 1863.

Camarotoechia orientalis (Billings) RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 223, pl. 33, figs. 32, 33, 1911.—TWHENHOFEL and WHITING, Geol. Soc. Amer. Special Pap. 11, p. 51, pl. 7, figs. 22-24, 1938.

A small shell frequently misidentified. The writer has seen few authentic examples of this species outside of the Mingan Islands. The specimens from St. Martin Junction, Quebec, identified as this species by Raymond are herein referred to a new species, *R. raymondi*. The one specimen of this species from Aylmer, Quebec, in Raymond's lot has the size and ornamentation of *R. orientalis* but is too crushed to make the identification positive. The species is not reported from New York.

Types.—Figured hypotypes: 111489, 111490a; G.S.C. 2184.

Horizon and locality.—Mingan formation, Mingan Islands, St. Lawrence River, Canada.

ROSTRICELLULA OVATA Cooper, new species

Plate 131, E, figures 33-39; plate 133, E, figures 27-35

Shell of about medium size, triangular in outline with the length and width nearly equal. Greatest width anterior to the middle; sides long and straight

forming an apical angle of about 82° . Anterolateral extremities narrowly rounded; anterior margin gently curved. Sulcus marked by 4 to 5 costae, the fold by 5 to 6 costae, and the flanks by 5 or 6 costae. Surface crossed by moderately strong fila.

Pedicle valve fairly evenly but gently convex in lateral profile; anterior profile gently depressed in the median region, precipitous on the sides. Beak narrow, incurved; umbo slightly swollen; sulcus originating about 7 mm. anterior to the beak; sulcus shallow and broad, occupying about half the width. Sulcus depressed slightly below the flanks at the front; flanks narrow, rounded, and steep.

Brachial valve deeper than the pedicle valve, moderately convex in lateral profile and with the umbonal region having the greatest curvature; anterior profile moderately arched. Fold broad and low, not strongly elevated at the front, and its place of origin not clear but near the middle; flanks strongly rounded and precipitous.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|----------------|--------|-----------------|-------|-----------|
| Holotype | 14.2 | 12.8 | 13.8 | 8.7 |
| Paratype | 14.4 | 13.1 | 12.8 | 8.9 |

Types.—Holotype: 117222; figured paratype: 111532.

Horizon and locality.—Dryden formation (=Wardell part) in Virginia: In a quarry just east of Virginia State Highway 70, north of Powell River, 1.6 miles south of Jonesville, Ben Hur (T.V.A. 170-NE) Quadrangle.

Same formation in Tennessee: At Mulberry Gap in Powell Mountain, 5 miles north of Sneedville, Sneedville (T.V.A. 170-SW) Quadrangle.

Hostler formation in Pennsylvania: At the National Lime Quarry, Shrader Station=Nagney Post Office, Lewistown (15') Quadrangle.

Ooltewah formation in Tennessee: $3\frac{1}{2}$ miles north of Ooltewah, Ooltewah (T.V.A. 112-SE) Quadrangle.

Discussion.—This species is characterized by having its length and width nearly equal but with the length often the greater, a low, wide fold, and sulcus marked by numerous costae. The species is very similar to *R. plena* of the Valcour limestone, New York, but does not attain the large size and robust form of that species. *Rostricellula plena* usually has deeper valves, with a more incurved pedicle beak and more numerous costae on the fold and in the sulcus. *Rostricellula ovata* differs from *R. rostrata* in its more elongate form and the fact that the greatest width is more anterior than that of *R. rostrata*. Furthermore, the fold of the latter species is more pronounced and the costae less numerous and more distant in *R. rostrata*.

ROSTRICELLULA PARVA Cooper, new species

Plate 134, C, figures 27-32

Shell small, triangular in outline, slightly wider than long; greatest width at about the middle; anterior margin nearly straight; apical angle slightly greater

than a right angle. Fold marked by 7 costae and the sulcus by 6 costae; flanks marked by 9 costae.

Pedicle valve gently convex in lateral profile, broadly and gently convex in anterior profile; sulcus shallow and wide, occupying about half the width; flanks gently rounded and moderately steep.

Brachial valve gently convex in lateral profile and with the greatest convexity at about the middle; anterior profile broadly rounded but only moderately convex; fold low, noticeably elevated at the front; flanks rounded and moderately steep.

Measurements in mm.—Holotype, length 7.8, brachial length 6.9, width 8.3, thickness 4.5.

Types.—Holotype: 117223a; unfigured paratype: 117223b.

Horizon and locality.—Bromide formation (Pooleville member) in Oklahoma: On Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is characterized by its small size, numerous costae on the fold and sulcus, and length and width nearly equal. The species is suggestive of *R. pristina* in size but has more numerous costae. It differs in the same respects from *R. orientalis*, *R. basalaris*, and *R. raymondi*.

ROSTRICELLULA PLATTINENSIS (Fenton)

Plate 132, H, figures 43-51

Protorhyncha plattinensis FENTON, Amer. Midland Nat., vol. 11, p. 135, pl. 3, figs. 21-24, 1928.

A small variable species originally assigned to *Protorhyncha*, to which genus it does not belong. Specimens from the type locality show the characteristic median septum and rostral chamber without a cardinal process of *Rostricellula*. The whole habit of the species is that of the latter genus rather than *Protorhyncha* or the new genus *Ancistrorhyncha*. Specimens of the latter occur with *R. plattinensis* but could not be confused with it as they are ornamented by fine costae or costellae and are without a median septum. The serial sections figured by Fenton (pl. 4, figs. 1-6) do not conform either to *Rostricellula* or *Ancistrorhyncha*.

Measurements in mm.—Hypotype (111491), length 10.5, brachial length 9.5, width 11.3, thickness 7.1.

Type.—Figured hypotype: 111491.

Horizon and locality.—Plattin group (lower) in Missouri: On the J. Heck place, 1¼ miles south-southeast of River Aux Vasses, Weingarten (15') Quadrangle.

Discussion.—The narrowly rounded fold of this species is its chief characteristic. The 2 median costae of the fold are elevated above the 2 lateral ones, thus producing a narrowly rounded fold when viewed in anterior profile. In this respect it is somewhat like *R. acutiplicata*, but that species is wider, differently ornamented, and with different proportions to the valves.

ROSTRICELLULA PLENA (Hall)

Plate 129, I, figures 39-53; plate 132, D, figures 19, 20; plate 137, E, figures 34-36

Atrypa plena HALL, Pal. New York, vol. 1, p. 21, pl. 4 bis, figs. 7a-c, 1847.

Camarotoechia plena (Hall) RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 221, pl. 33, figs. 7-18, 1911.

For full synonymy see Bassler, U. S. Nat. Mus. Bull. 92, p. 178, 1915.

Attains a large size and is one of the biggest of the known species of this genus. Occurs in great abundance in the Valcour formation in the vicinity of Chazy and on Valcour Island. Raymond has discussed the variation of the species and concludes that *Atrypa altilis* and *A. plicifera* are variations of *A. plena*.

The adult is generally subtriangular in outline, with the length and width about equal; maximum width at or a short distance anterior to the middle. Surface marked by 17 to 24 costae, 5 to 7 in the sulcus and 1 more on the fold. The sulcus of the pedicle valve originates about 5 mm. anterior to the beak and usually occupies from one-half to three-fourths the width at the front; flanks flattened and with moderately steep slopes. Brachial valve strongly convex in both profiles with more or less prominent fold originating anterior to the sulcate umbo. Fold gently rounded in profile, moderately elevated above the flanks anteriorly; flanks rounded and with steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|---------------------------------|--------|-----------------|-------|-----------|
| Figured hypotype (III1510)..... | 17.0 | 15.5 | 16.4 | 11.9 |
| “ “ (III497a)..... | 16.8 | 15.2 | 17.7 | 13.6 |
| “ “ (III409a)..... | 15.7 | 13.7 | 14.8 | 11.3 |

Types.—Holotype: A.M.N.H. 530/1; figured hypotypes: III497a, III509, III1510, G.S.C. 1040; measured hypotype: III409a.

Horizon and locality.—Valcour formation in New York: Abundant in the vicinity of Chazy, Rouses Point (15') Quadrangle, and on Valcour Island, Plattsburg (15') Quadrangle.

St. Martin formation in Quebec, Canada: At Montreal.

Aylmer formation in Canada: In the Ottawa Valley.

Row Park formation in Pennsylvania: From a cut on Pennsylvania Highway 995, south of Conococheague Creek, 1 mile north of Welsh Run (identification doubtful), Mercersburg (15') Quadrangle.

Discussion.—*Rostricellula plena* is one of the largest and most robust species of this genus. It is characterized by a low but wide fold and sulcus, both occupied by numerous costae. The brachial valve is much deeper than the pedicle valve and is strongly swollen and convex. Although this species is one of the earliest of the genus, its large size and robust form mark it as an advanced type. The only Appalachian species approaching this one in size is *R. tumidula*. The two species, however, are not likely to be confused because *R. tumidula* is more strongly costate, has a more shallow sulcus and lower fold, and somewhat less strongly convex valves.

ROSTRICELLULA PLENA ALTILIS (Hall)

Plate 130, D, figures 20-24

Atrypa altilis HALL, Pal. New York, vol. 1, p. 23, pl. 4 bis, figs. 9a-d, 1847.

This subspecies in its extreme form can be readily distinguished from *R. plena* by the compressed form and crowding of the costae. The variety seems to grade into normal forms of the species. Common in places.

Type.—Holotype: A.M.N.H. 532/1.

Horizon and locality.—Valcour formation in New York: On the road along Little Monty Bay, $\frac{1}{2}$ mile north of Bocar Point, southeast of Chazy, and at Chazy, Rouses Point (15') Quadrangle.

ROSTRICELLULA PLENA PLICIFERA (Hall)

Plate 130, C, figures 18, 19

Atrypa plicifera HALL, Pal. New York, vol. 1, p. 22, pl. 4 bis, figs. 8a-d, 1847.

This name can be applied to a depressed shell with somewhat more spreading costae and rounder form than is usual in the species. Hall's type specimen is somewhat crushed, and this may be the reason for the characters exhibited. As all the limestones of the Lake Champlain region have been much deformed, it is possible that some of the variation of the contained shells is due to deformation during the squeezing of the limestone. A specimen almost identical with Hall's type occurs with specimens that show other deformation.

Type.—Holotype: A.M.N.H. 533.

Horizon and locality.—Valcour formation in New York: On the west side of New York Highway 22, on Kennon Brook, $\frac{1}{2}$ mile south of East Beekmantown, Plattsburg (15') Quadrangle; Chazy, Rouses Point (15') Quadrangle.

ROSTRICELLULA PRISTINA (Raymond)

Plate 132, B, figures 6-10

Camarotoechia pristina RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 368, 1905; Ann. Carnegie Mus., vol. 7, No. 2, p. 225, pl. 24, figs. 1-10, 1905.

Type.—Figured hypotype; A.M.N.H. 25047/2.

Horizon and locality.—Crown Point formation in New York: Sloop Bay, Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This species is characterized by its small size and the presence of 3 costae in the sulcus and 4 on the fold. Preliminary identifications of small Rostricellulas from the Lenoir of the Southern Appalachians were made with this species, but closer examination of the specimens and comparison with topotypes of *R. pristina* indicate different species. The Lenoir species is now referred to *R. basalaris* and other species.

ROSTRICELLULA PULCHRA Cooper, new species

Plate 135, E, figures 26-35

Shell of about medium size, wider than long; greatest width at or near the middle; apical angle nearly 100° ; anterior margin truncated. Sulcus having 3

or 4 costae, the fold having 4 or 5 costae, and the flanks marked by as many as 10 costae.

Pedicle valve gently convex in lateral profile with the maximum curvature between the umbo and the middle; anterior profile flattened or concave medially and with steep lateral slopes. Sulcus originating 5 or 6 mm. anterior to the beak. Sulcus deepening anteriorly from the middle of the valve, never very deep even at the anterior end. Tongue moderately long. Flanks flattened and with moderately steep slopes.

Brachial valve of about equal depth to that of the pedicle valve; lateral profile gently convex; anterior profile broadly convex and with precipitous sides. Umbo gently swollen, narrowly sulcate. Fold originating near the middle of the valve, not strongly elevated even at the front. Flanks swollen and only slightly depressed below the fold; lateral slopes steep.

Measurements in mm.—

| | Length | Brachial length | Thickness | Width |
|----------------|--------|-----------------|-----------|-------|
| Holotype | 12.0 | 11.1 | 13.7 | 8.7 |
| Paratype | 10.8 | 10.0 | 11.8 | 7.6 |

Types.—Holotype: 117224b; unfigured paratype: 117224a.

Horizon and locality.—Decorah formation (Guttenburg member-*Rhinidictya* bed) in Minnesota: In the Mississippi River bluffs at St. Paul.

Discussion.—This species has a broad, low fold and sulcus, broad outline with the midwidth forming the widest part, and a fairly large apical angle. The species is somewhat intermediate between *R. minnesotensis* and *R. colei*. From the former it differs in having a much less rotund profile and smaller and more numerous costae; it differs from the latter in being much smaller and having a wider fold. It appears to be a more robust shell than *R. missouriensis* and differs from *R. decorahensis* in being wider and more numerously costate.

ROSTRICELLULA RAYMONDI Cooper, new species

Plate 130, E, figures 25-34; plate 130, F, figure 35; plate 132, C, figures 11-18

Camarotoechia orientalis RAYMOND (part), Ann. Carnegie Mus., vol. 7, No. 2, p. 223, pl. 35, figs. 19-22, 24-31 (not 32 and 33), 1911.

Shell of about medium size for the genus, subelliptical to subtriangular in outline; beak ranging from a right angle to obtuse; sides narrowly rounded; front margin subnasute; surface costate, generally 3 costae marking the sulcus (occasionally 4) and 4 the fold (occasionally 5), with the flanks occupied by 6 or 7 costae, the last 3 or 4 obscure.

Pedicle valve gently convex in lateral profile with the most convex part located in the posterior half; umbonal region narrowly convex; sulcus originating about 5 mm. anterior to the beak, deep and occupying more than half the width at the front; tongue moderately long; flanks flat in profile and with moderate slopes to the margins. Costae forming margin of sulcus elevated strongly anteriorly above the sulcus to form pointed extremities.

Brachial valve about equal to the pedicle valve in depth, gently convex in

profile with the greatest curvature in the umbonal region; umbo slightly sulcate, somewhat swollen on the sides; fold low posteriorly but strongly elevated anteriorly; rounded in profile with the median 2 costae standing above the flanking ones; anterolateral extremities depressed toward the pedicle valve; flanks moderately convex, posterolateral slopes nearly vertical.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------------------|--------|-------|-----------|
| Holotype | 13.6 | 15.4 | 9.1 |
| Paratype (Carnegie Mus. 2174) | 12.2 | 13.0 | 8.2 |

Types.—Holotype: Carnegie Mus. 2176; figured paratypes: Carnegie Mus. 2174, 2175, U.S.N.M. 117225; unfigured paratypes: Carnegie Mus. 2172, 2173, 2177-2179.

Horizon and locality.—St. Martin formation in Quebec, Canada: St. Martin Junction, near Montreal.

Crown Point (or Valcour) formation in New York: On Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This species differs from *R. orientalis* (Billings) in its less carinate fold which is much less elevated anteriorly and has a proportionately shorter tongue. The anterolateral extremities of *R. orientalis* are much more narrowly rounded than those of the shell from St. Martin Junction. Furthermore, *R. orientalis* attains only about half the size of *R. raymondi*.

ROSTRICELLULA ROSTRATA Ulrich and Cooper

Plate 131, B, figures 8-16; plate 131, F, figures 40-46; plate 136, B, figures 23-34;
plate 136, C, figures 35-49

Rostricellula rostrata ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 626, pl. 90, figs. 24, 28, 29, 32, 37, 1942.

Shell of about medium size for the genus, triangular to subpentagonal in outline; brachial valve slightly deeper than the pedicle; beak forming approximately a right angle; greatest width at or slightly anterior to the middle; anterolateral margins narrowly rounded, front margin broadly rounded. Surface costate, 3 to 5 costae occupying the sulcus and 4 to 6 defining the fold; flanks marked by 6 costae. Entire surface marked by fine radial and concentric lines that produce granules where they intersect.

Pedicle valve moderately convex with the greatest convexity located from the middle to the umbo. Posterior quarter and umbonal region moderately convex; sulcus originating about 6 mm. anterior of the beak, flat in profile, shallow, and producing a short truncated tongue anteriorly. Sulcus occupies more than half the width at the front. Flanks gently convex and with moderately steep slopes to the margins.

Brachial valve evenly and strongly convex in lateral profile and strongly convex in anterior profile; greatest convexity near the middle. Umbonal region swollen; the fold originates about 5 mm. anterior to the brachial beak; posterior to the fold a shallow and poorly defined sulcus marks the shell. Fold low, spread-

ing gradually anteriorly, gently convex in profile; flanks moderately convex and with moderately steep slopes to the margins.

Interior: Teeth small, supported by short dental plates separated from the outside wall of the shell by narrow umbonal cavities; pedicle callist slightly thickened. Brachial valve with a high and thin median septum supporting a short, shallow, and narrow cruralium which in turn supports a divided hinge plate. Crura long, slender and curved.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 14.3 | 12.7 | 14.4 | 8.6 |
| Paratype (108205c) | 15.3 | 13.8 | 15.3 | 9.3 |

Types.—Holotype: 108205a; figured paratypes: 108205b-d,h; unfigured paratypes: 108205e,f,g; figured hypotypes: 111531a,b, 111535, 111541a-c, 117226a,b, 117227.

Horizon and locality.—Wardell formation in Tennessee: 7 miles southwest of Clinton, Clinton (T.V.A. 137-SW) Quadrangle; 1½ to 2 miles northeast of Loyston, Maynardville (30') Quadrangle.

Dryden formation in Tennessee: On the road to Tazewell, 1½ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle.

Ridley formation in Tennessee: 1 mile west of the courthouse in Murfreesboro, Murfreesboro (15') Quadrangle.

Pierce formation in Tennessee: At Murfreesboro, Murfreesboro (15') Quadrangle.

Wardell part of Dryden formation in Virginia: In a quarry just east of Virginia Highway 70, northeast of the Powell River, 1.6 miles south of Jonesville, Ben Hur (T.V.A. 170-NE) Quadrangle; quarry on Station Creek, ½ mile south of U. S. Highway 58, 2 miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle.

Discussion.—This is a fairly large species with somewhat distant costae, a moderately wide fold and sulcus, and triangular outline. It differs from *R. plena* in its lesser convexity and more distant costae. It is suggestive of *R. truncata*, but that species is much more strongly costate and is truncated anteriorly. *Rostricellula tumidula* is a strongly costate Appalachian form, but its large size and somewhat swollen valves are not likely to be confused with *R. rostrata*.

Rostricellula rostrata as here described and figured may be a composite species. Specimens from the Benbolt-Wardell=Dryden shale with *Dinorthis transversa* on the Tazewell road 1½ miles northeast of Lone Mountain are not quite characteristic in profile and are somewhat less wide anteriorly. These features may be old age characters.

ROSTRICELLULA ROTUNDATA Cooper, new species

Plate 139, B, figures 12-22

Shell fairly large, somewhat elliptical in outline with the width greater than the length; sides narrowly rounded; anterior margin nearly straight to slightly

convex; apical angle about 115° ; sulcus occupied by 4 to 6 costae, fold by 5 to 7 costae, flanks with 9 costae. Surface marked by fine fila, often papillose.

Pedicle valve gently convex in lateral profile; broadly convex in anterior profile but with the median region gently concave. Sulcus originating about 6 mm. anterior to the beak; umbo somewhat swollen. Sulcus broad and shallow; tongue moderately long. Median area swollen. Flanks flattened, moderately steep.

Brachial valve deeper than the pedicle valve, strongly convex in lateral profile, broadly arched in anterior profile. Umbo swollen; median region swollen and forming the most convex part of the valve; umbo moderately sulcate; fold low and with rounded profile; width of fold at front about one-third the valve width. Flanks rounded but with moderate slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|-----------------|-------|-----------|
| Holotype | 11.7 | 9.9 | 13.7 | 8.6 |
| Paratype (3655ob) | 11.0 | 9.9 | 13.4 | 9.1 |
| " (3655oc) | 9.1 | 8.6 | 11.7 | 6.6 |
| " (3655od) | 8.2 | 7.2 | 8.8 | 5.3 |

Types.—Holotype: 3655oa; figured paratype: 3655ob; measured paratypes: 3655oc,d.

Horizon and locality.—Swift Current formation in Ontario, Canada: North-east corner of St. Joseph Island, St. Marys River.

Discussion.—This species has been referred to *R. ainslei* and is quite suggestive of that form because of its rounded contours, low beak, and transversely elliptical outline. In spite of the similar appearance it is quite different. *Rostricellula rotunda* is generally smaller than *R. ainslei*, is more rotund in lateral profile, and has a lower and narrower fold.

ROSTRICELLULA SUBTRANSVERSA Cooper, new species

Plate 137, B, figures 7-19

Shell of about medium size for the genus, wider than long, with narrowly rounded sides and somewhat truncated anterior margin. Apical angle varying between 90° and 100° . Sulcus marked by 5 or 6 costae, the fold by 6 or 7, and the flanks by 6 to 10 costae. Entire surface crossed by fine elevated fila.

Pedicle valve gently convex in both profiles; umbo convex, beak strongly incurved. Sulcus originating 4 to 5 mm. anterior to the beak, broad and shallow. Tongue moderately long. Flanks narrowly rounded and with moderate slopes.

Brachial valve considerably deeper than the pedicle valve, strongly convex in lateral profile, and strongly arched with steep sides in anterior profile. Fold low, not strongly defined at any point on its length; median region strongly inflated; flanks swollen and precipitous.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 9.8 | 8.8 | 12.1 | 7.6 |
| Paratype (117228a) | 12.3 | 11.5 | 13.0 | 9.7 |
| " (117228c) | 9.2 | 8.6 | 11.0 | 5.4 |

Types.—Holotype: 117228b; figured paratypes: 117228a,c.

Horizon and locality.—Witten formation in Tennessee: $\frac{1}{2}$ mile south of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle; near Luttrell.

Discussion.—This species has been confused with *R. ainslei*, but it is much smaller and has different proportions. It is much more likely to be confused with *R. rotunda* because, like that species, it has smooth rounded outlines and moderate size. *Rostricellula rotunda*, however, has a less prominent fold in the adult condition, is less deeply sulcate and somewhat deeper. *Rostricellula transversa* is similar but is less numerously costate and is more strongly folded.

ROSTRICELLULA TRANSVERSA Cooper, new species

Plate 132, G, figures 38-42; plate 134, E, figures 47-53; plate 137, H, figures 53-60

Shell of about medium size for the genus with the width equal to about $1\frac{1}{4}$ times the length; beak obtusely angular, posterolateral margins straight, sides narrowly rounded. Front margin truncated. Surface costate, 3 to 4 costae occupying the sulcus and 4 to 5 forming the fold; flanks with as many as 8 costae.

Pedicle valve moderately convex with the greatest convexity located in the posterior half. Umbo swollen and convex; sulcus originating about 4 mm. anterior to the beak, widening anteriorly to occupy about half the width at the front. Tongue moderately long, truncated anteriorly. Umbonal slopes steep; flanks flattened in profile and with only moderately steep slopes to the margins. Interarea small.

Brachial valve slightly deeper than the pedicle valve, evenly but moderately convex with the maximum convexity at about the middle. Umbonal region flattened; umbo marked by a slight depression posterior to the fold which originates about $2\frac{1}{2}$ mm. anterior to the beak. Fold flattened in anterior profile, moderately elevated above the flanks. Steep slopes and a rounded profile characterize the flanks.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 8.1 | 7.3 | 10.6 | 5.8 |
| Paratype (111545b) | 9.1 | 8.7 | 11.9 | 6.2 |
| “ (117229a) | 10.2 | 9.3 | 11.7 | 7.0 |

Types.—Holotype: 111545a; figured paratype: 117229a; figured specimen: 117230; measured paratype: 111545b.

Horizon and locality.—Bromide formation (Pooleville member) in Oklahoma in Murray County: 15 feet below the top of the formation on Colbert Creek, SW $\frac{1}{4}$ sec. 15, T. 1 S., R. 1 E., 5 miles southwest of Davis; Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County; in Pontotoc County on Oklahoma Highway 99, 3 miles south of Fittstown. Mountain Lake, E $\frac{1}{2}$ sec. 22, T. 2 S., R. 1 W., Carter County; NE $\frac{1}{4}$ sec. 32, and SE $\frac{1}{4}$ sec. 33, T. 2 S., R. 2 E., in Carter County; $\frac{1}{4}$ mile west of U. S. Highway 77, sec. 25, T. 2 S., R. 1 E., north of Ardmore, Carter County.

Discussion.—This species suggests a small *R. laticosta* (Winchell and Schuchert) but is more numerous costate. The species resembles *R. rotunda* but does not attain the large size of that species nor does it have as deep a sulcus. This species as here identified is somewhat variable. More extensive collections will probably indicate further refinement of the species.

ROSTRICELLULA TRIANGULATA Cooper, new species

Plate 133, A, figures 1-11

Camarotoechia pristina TWENHOFEL and WHITING (not Raymond), Geol. Soc. Amer. Special Pap. 11, p. 52, pl. 8, figs. 1, 2, 1938.

Shell small, triangular in outline with acute beak (72°) and nearly straight sides to the anterolateral extremities which are narrowly rounded. Anterior margin broadly rounded. Brachial valve slightly deeper than the pedicle valve. Surface costate, sulcus occupied by 4 or 5 costae, the fold by 5 or 6, and the flanks by about 5.

Pedicle valve gently but evenly convex in lateral profile, posterior half moderately convex, with a long narrow beak and narrowly rounded umbo; sulcus originating about 4 mm. anterior to the beak and near the middle of the valve, shallow, flat to convex in profile; tongue short and broadly rounded. Anterolateral extremities moderately elevated; flanks narrowly convex and with steep lateral slopes.

Brachial valve gently convex with the maximum convexity in the median region; broadly convex in anterior profile; fold not conspicuous, only slightly elevated at the front; flanks rounded and with moderately steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|----------------|--------|-----------------|-------|-----------|
| Holotype | 7.2 | 6.4 | 7.2 | 4.0 |
| Paratype | 6.7 | 6.1 | 6.0 | 3.3 |

Types.—Holotype: 111549a; figured paratype: 111549b.

Horizon and locality.—Mingan formation (60 to 70 feet above the base): Bald Island, Mingan group, St. Lawrence River, Quebec, Canada.

Discussion.—This species differs from *R. pristina*, with which it was formerly confused, in its more triangular form and more numerous costae in the fold and sulcus. It differs in the same respects from *R. basalaris*. It is more finely costate than *R. costata* and is not so deep as that species.

ROSTRICELLULA TRUNCATA Cooper, new species

Plate 134, B, figures 19-26

Shell of about medium size for the genus, wider than long, and broadly triangular in outline. Apical angle about 100° . Posterolateral margins straight, anterolateral extremities narrowly rounded; anterior margin truncated. Costae strong, narrowly rounded, 4 on the fold, 3 in the sulcus, and 4 to 6 on the flanks.

Pedicle valve shallow and only gently convex in lateral profile, broadly concave

in anterior profile. Sulcus originating about 5 mm. anterior to the beak, broad and shallow; tongue short, truncated. Flanks narrow and steep sided.

Brachial valve slightly deeper than the pedicle valve, gently convex in lateral profile; broadly convex in anterior profile and somewhat flattened in the middle; fold originating just posterior to the middle, flattened, not strongly elevated. Flanks narrowly rounded and steep sided.

Measurements in mm.—Holotype, length 13.3, brachial length 11.8, width 15.8, thickness 9.6.

Type.—Holotype: 117231.

Horizon and locality.—Lebanon formation in Tennessee: On U. S. Highway 41, $\frac{3}{4}$ mile south of Knox Branch, 9 miles southeast of Murfreesboro, Rutherford County.

Discussion.—This species is characterized by its strong and distant costae and the marked truncation of the anterior end. It is most like *R. angulata* in its strong costation but differs in its anterior truncation and in having more numerous costae on the fold and in the sulcus.

ROSTRICELLULA TUMIDULA Cooper, new species

Plate 131, C, figures 17-27

Shell large for the genus, subtriangular in outline; valves subequal in depth. Beak approximating a right angle; anterolateral extremities narrowly rounded; anterior margin broadly rounded to nasute. Surface costate, sulcus occupied by 5 to 7 narrowly rounded to subangular costae separated by spaces equal in width to the costae; fold marked by 6 to 8 costae and the flanks by 5 to 7 costae.

Pedicle valve moderately convex in lateral profile, with the greatest convexity at about the middle; posterior third and umbonal region gently swollen; sulcus originating about 7.5 mm. anterior to the beak; sulcus broad and shallow, equal in width to more than half the width of the valve; tongue moderately long, broadly rounded. Flanks moderately rounded and with moderate slopes to the margins.

Brachial valve fairly strongly convex in lateral profile and with the maximum curvatures at about the middle. Fold not strongly defined, originating about 6 mm. anterior to the beak, gently rounded in anterior profile; only slightly elevated at the front. Flanks rounded in profile but with steep lateral slopes. Umbonal and median regions swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|-----------------|-------|-----------|
| Holotype | 20.6 | 18.1 | 20.1 | 13.3 |
| Paratype (98196a) | 18.3 | 16.7 | 16.6 | 12.8 |
| " (98196c) | 17.5 | 15.5 | 17.9 | 12.0 |

Types.—Holotype: 98196b; figured paratypes: 98196a, c.

Horizon and locality.—Dryden formation in Virginia: $\frac{1}{2}$ mile west of Fullers Corner, 1 mile south-southeast of Big A Mountain, Big A Mountain (T.V.A. 204-SE) Quadrangle.

Discussion.—The large size and tumid form of this species suggest *R. plena*, but that species possesses more numerous costae and more triangular form. *Rostricellula tumidula* approaches *R. major* in size but differs in having more and finer costae.

ROSTRICELLULA VARIABILIS Cooper, new species

Plate 133, C, figures 13-19; plate 133, D, figures 20-26

Shell of about medium size, outline variable from oval to subtriangular with length greater or less than width; apical angle varying from 85° to 100° . Sulcus with 4 or 5 rounded costae, fold with 5 or 6 costae, and the flanks with 6 or 7 costae.

Pedicle valve gently convex in lateral profile, with the maximum curvature in the umbonal region. Anterior profile broadly or flatly convex. Sulcus originating about 4 mm. anterior to the beak, shallow throughout its extent. Tongue short. Sulcus occupying more than half the width. Flanks narrow and rounded with steep sides.

Brachial valve deeper than the pedicle valve, moderately convex in lateral profile, fairly strongly convex in anterior profile. Umbonal region flattened and narrowly sulcate. Fold low throughout its length, only slightly elevated above the flanks anteriorly. Flanks swollen, rounded and with precipitate sides.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|----------------|--------|-----------------|-------|-----------|
| Holotype | 13.3 | 12.1 | 11.9 | 7.2 |
| Paratype | 10.0 | 9.5 | 10.8 | 7.1 |

Types.—Holotype: 117232; figured paratype: 117233.

Horizon and locality.—Ridley formation (*Fascifera* bed) in Georgia: 1 mile south-southeast of Cove Church, 5 miles south of Chickamauga, Kensington (T.V.A. 106-SE) Quadrangle.

Discussion.—This species is characterized by its moderate size, subtriangular form and moderately wide sulcus with 4 or 5 costae. It shows considerable variation in the development of the fold and sulcus, the larger specimens having the anterior somewhat elongated or subnasute and the costae more spread out than in the younger stages. The elongate form suggests *R. ovata* because of its length but is not so numerously costate. The younger forms are not unlike *R. pulchra* or *R. missouriensis*. It differs from the former in much smaller size and in having a somewhat narrow and more pronounced fold than those features on the corresponding size in *R. pulchra*. *Rostricellula missouriensis* in stages having the same length as *R. variabilis* is not so deep and has a wider and more pronounced fold.

ROSTRICELLULA VARICOSTA Cooper, new species

Plate 139, C, figures 23-36

Shell small, variable in outline and costation; subtriangular to oval in outline; apical angle varying from about 85° to 100° . Posterolateral margins straight;

anterolateral margins narrowly rounded; anterior margin broadly rounded; surface marked by rounded costae: 4 to 7 on the fold, 3 to 6 on the sulcus, and 5 to 8 on the flanks.

Pedicle valve with lateral profile fairly evenly and moderately convex; anterior profile broadly and gently convex; umbonal and median regions somewhat narrowly swollen; sulcus originating at the middle, shallow and wide; tongue broadly rounded but fairly short. Flanks narrowly rounded, with steep sides.

Brachial valve moderately convex in lateral profile, fairly strongly convex in anterior profile; umbonal and median regions moderately swollen; sulcus originating at about the middle, low throughout its length and not markedly differentiated from the flanks which are swollen and have steep slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Max. width | Thickness |
|--------------------------|--------|-----------------|------------|-----------|
| Holotype | 8.6 | 7.8 | 9.5 | 5.2 |
| Paratype (117238b) | 9.0 | 8.2 | 8.9 | 6.4 |
| “ (117238c) | 9.5 | 8.7 | 9.9 | 6.2 |
| “ (117238d) | 9.1 | 8.2 | 9.1 | 5.3 |
| “ (117238e) | 7.8 | 7.2 | 7.8 | 4.5 |

Types.—Holotype: 117238a; figured paratype: 117238b; unfigured paratypes: 117238c-e.

Horizon and locality.—Lenoir formation (Douglas Lake member) in Tennessee: 0.65 mile southwest of Williamson Chapel, Tallassee (T.V.A. 139-SE) Quadrangle.

Discussion.—This species is characterized by moderate size, nearly equal length and maximum width, wide fold and sulcus, and numerous costae. Although it suggests *R. raymondi*, that species is much more strongly costate. *Rostricellula basalaris* occurs at about the same level but is more triangular in outline and is somewhat more strongly costate. *Rostricellula multicostata* also occurs at the same level, but it is much larger and has a more pronounced fold which is marked by about the same number of costae as in the Tennessee species. However, the Virginia species has more costae on the flanks than the Tennessee form.

The base of the Lenoir or its equivalent in many places in the Appalachian Valley is marked by abundance of *Rostricellula*. Often the rock is so filled with these rhynchonellid shells that no other species are to be found. It is odd that from place to place these shells seem to vary specifically. They were undoubtedly controlled by environmental conditions that varied geographically. Evidence of such geographic variation is encountered also in other places and other strata and will one day form a fruitful subject for investigation.

ROSTRICELLULA WILSONAE Cooper, new species

Plate 135, F, figures 36-48

Shell of about medium size for the genus, slightly wider than long, sides narrowly rounded and greatest width just anterior to the middle. Apical angle ap-

proximately 90°. Sulcus marked by 4 to 6 narrowly rounded, slender costae, fold marked by 5 to 7 costae, and the flanks by 7 or 8 costae.

Pedicle valve unevenly and gently convex in lateral profile, the most convex part located just anterior to the umbo; anterior profile broadly convex and with the median region slightly depressed. Beak strongly incurved and overhanging the umbo of the brachial valve. Umbo moderately swollen; sulcus originating just posterior to the middle or about 5 mm. anterior to the beak. Sulcus moderately deep; tongue short, not geniculated. Flanks flat, moderately sloping.

Brachial valve deeper than the pedicle valve, moderately convex in lateral profile, moderately strongly arched in anterior profile. Umbo strongly swollen, marked medially by a shallow and narrow sulcus. Fold becoming defined near the middle, not strongly elevated at any point on its length. Flanks rounded and moderately steep.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|----------------|--------|-----------------|-------|-----------|
| Holotype | 11.8 | 10.7 | 12.9 | 7.2 |
| Paratype | 11.7 | 10.3 | 10.6 | 8.9 |

Types.—Holotype: 117234a; figured paratype: 117234b.

Horizon and locality.—Aylmer formation (Rockcliffe member) in Ontario, Canada: 2 miles south of Rockland.

Discussion.—This species has been commonly referred to *R. plena* in the region around Ottawa. In appearance *R. wilsonae* is suggestive of that species but does not attain its large size or great depth. *R. plena* of the same size as *R. wilsonae* is much deeper, has a shallower sulcus and a more triangular shape than the Ottawa species. The deeper varieties of *R. wilsonae* compared with specimens of *R. plena* of the same length have a deeper sulcus.

ROSTRICELLULA sp. 1

Plate 137, G, figures 47-52

Small, length and width nearly equal; fold marked by 3 costae, the sulcus by 2. Flanks marked by 5 or 6 costae. Valves subequal in depth; sulcus originating near the middle; fold low; tongue short.

Measurements in mm.—Figured specimen, length 6.2, brachial length 5.5, width 6.4, thickness 4.8.

Figured specimen.—117236.

Horizon and locality.—Bromide formation (Pooleville member—bed E of Cooper) in Oklahoma: On Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—A single specimen was found in this bed of the Bromide, and no other members of the genus were taken from that part of the column. The present specimen, in its thickened shell and strongly marked interrupted growth stages, is obviously not a normal specimen. Abnormality is further emphasized by the presence of a bifurcated costa which is exceptional in this genus of rhynchonellids.

ROSTRICELLULA sp. 2

Plate 131, D, figures 28-32

Shell small, length and width about equal; apical angle about 95° . Greatest width anterior to the middle. Costae numbering 5 on the fold, 4 in the sulcus, and 7 or 8 on the flanks.

Pedicle valve slightly less deep than the brachial valve and with a moderately convex lateral profile. Anterior profile broadly and gently convex. Sulcus originating 5 mm. anterior to the beak; umbo gently rounded; sulcus shallow, occupying about half the width. Tongue long and narrow. Flanks narrow and steeply descending to the margins.

Brachial valve with lateral profile like that of the pedicle valve; anterior profile moderately strongly convex; umbonal region moderately swollen; fold low and rounded, not elevated strongly at the anterior. Flanks rounded and with precipitous sides.

Measurements in mm.—117235, length 8.1, brachial length 7.4, width 8.3, thickness 5.7.

Figured specimen.—117235.

Horizon and locality.—Upper Wardell formation in Virginia: At Mannville School, Clinchport (T.V.A. 188-NW) Quadrangle.

Same (?) horizon in Tennessee: On Little Mulberry Creek on the road up Sycamore Valley, Back Valley (T.V.A. 161-SE) Quadrangle.

ROSTRICELLULA sp. 3

Plate 139, E, figure 54

A figure of this specimen is introduced to show the character of the micro-ornamentation common to many species of *Rostricellula*. This consists of fine, wavy, concentric fila. These are irregular and often somewhat discontinuous. They are also variable in the degree to which they approach fine lamellae and are often longer in the swales between the costae than on the sides and are frequently worn off the crests of the costae. In places where variable in length these fila or minute lamellae give the impression that the surface is granulose.

Figured specimen.—117237.

Horizon and locality.—Lower Prosser formation in Minnesota: In the road cut 1.2 miles east of U. S. Highway 52 on the south edge of Cannon Falls, Goodhue County.

Family LEPIDOCYCLIDAE Cooper, new family

Rhynchonellacea with concave deltidial plates (?) in the pedicle valve and a cardinal process in the brachial valve.

Genus LEPIDOCYCLUS Wang, 1949

Lepidocyclus WANG, Geol. Soc. Amer. Mem. 42, p. 12, 1949.

LEPIDOCYCLUS sp. 1

Plate 130, G, figures 36, 37

Views of the interior of the pedicle and brachial valves of *Lepidocyclus* are introduced for comparison with the same views of *Rostricellula* and *Rhynchotrema*.

Figured specimens.—117209a,b.

Horizon and locality.—Fernvale formation, in Oklahoma: Quarry at Lawrence, southwest of Ada, Pontotoc County.

Family OLIGORHYNCHIIDAE Cooper, new Family

Small, strongly costate shells with small triangular deltidial plates and strong dental lamellae in the pedicle valve; brachial valve with long crura supported by delicate, discrete plates.

Genus OLIGORHYNCHIA Cooper, 1935

Oligorhynchia COOPER, Amer. Journ. Sci., vol. 29, p. 49, 1935.

Shell small, triangular in outline, biconvex; beak nearly straight. Anterior commissure intraplicate. External surface costate. Foramen elongate-oval, deltidial plates small, triangular.

Dental plates of pedicle valve strong, divergent; teeth long and slender, curved.

Notothyrial cavity long, moderately deep, narrow; sockets deep; socket ridges high; hinge plate divided, supported by thin, delicate convergent plates; crural bases triangular; crura long, nearly straight or curved, and extending almost directly anteriorly or obliquely toward the pedicle valve. Hinge plate supported by inner swelling of posterior of valve which forms the median sulcus at the posterior of the brachial valve. Musculature unknown.

Genotype.—*Oligorhynchia subplana* Cooper, Amer. Journ. Sci., vol. 29, p. 49, 1935.

Discussion.—Acquisition of material that could be etched to expose the crural plates well is the basis for the revised generic description above. The specimens came from the belt of shale and limestones (Hogskin member of the Lincolnshire formation) that extends from Thorn Hill, Tenn., to Washburn, Luttrell, and Speers Ferry, the same belt that produced the type specimens. The new material presents the hinge plate and shows it to be attached to the inner swelling of the valve produced by the sulcus at the posterior end and further supported by delicate converging plates. This sulcus in a short distance suddenly reverses to become a strong median elevation. The hinge plate is divided and consists of triangular outer hinge plates and strong, elevated socket plates that define the deep socket. The crura are shown by three specimens to have been long simple rods extending nearly straight into the valve in an anterior direction. A third specimen somewhat deeper than the others and approaching *O. subplana gibbosa* shows the crura to be curved and extended obliquely toward the pedicle valve.

Oligorhynchia is at present known only from the Southern Appalachians in the United States. It is also present, if interpretation of Cowper-Reed's figures is correct, in the Balclatchie and Stinchar limestones of the Girvan District, Scotland. The specimens described by Cowper-Reed as *Camarella ? conybearei* seem to belong to this genus, at least from their external appearance. No details of the interior are given in the description, but figure 23 on plate 22 (Reed 1917) shows short dental plates not unlike those seen in *Oligorhynchia* in the Appalachians.

OLIGORHYNCHIA ANGULATA Cooper

Plate 125, C, figures 37-46; plate 125, D, figures 47-49; plate 126, C, figures 10-12;
plate 127, B, figures 9-13

Oligorhynchia angulata COOPER, Amer. Journ. Sci., ser. 5, vol. 29, p. 52, pl. 1, figs. 6, 7, 9-11, 1935.

Types.—Lectotype: Y.P.M. S2258; figured hypotypes: U.S.N.M. 117195a-c, 117196, 118017; paratype: Y.P.M. S2259.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: At Luttrell, Luttrell (T.V.A. 155-NW) Quadrangle, and Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; on the road to Washburn, 3, 4, and $4\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; $\frac{3}{4}$ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; $\frac{1}{2}$ mile southwest of Fleanor Mill and 200 yards north of the highway, Powell Station (T.V.A. 137-SE) Quadrangle.

Sevier formation in Tennessee: $\frac{1}{4}$ mile north of Gooseneck, southwest corner Louisville (T.V.A. 138-SE) Quadrangle; slope on the west side of the church in Guthrie Gap, 2 miles south-southeast of Whitehorn, Bulls Gap (T.V.A. 171-SE) Quadrangle; 1.3 miles south of the center of Athens, Athens (T.V.A. 125-NE) Quadrangle.

Ward Cove formation in Virginia: On Wallen Creek, east of Virginia Highway 70 at Glass's store, $5\frac{1}{2}$ miles southeast of Jonesville, Ben Hur (T.V.A. 170-NE) Quadrangle.

OLIGORHYNCHIA BIFURCATA Cooper, new species

Plate 126, D, figures 13-24; plate 127, A, figures 1-8

Oligorhynchia sp. BUTTS, Virginia Geol. Surv. Bull. 52, pl. 87, figs. 18, 19, 1942.

Shell small, elongate triangular in outline, compressed in both profiles; beak erect and sharply pointed; surface strongly costate.

Pedicle valve with deep sulcus extending from beak to anterior margin and occupied by a single costa located in the front third of the sulcus. Sulcus bounded by strong angular, elevated costae with 2 low costae on each side.

Brachial valve faintly sulcate at the umbo but with a widening sulcus anteriorly which is occupied by a single strong costa bifurcated at its front end to accommodate the small costa of the pedicle sulcus. Flanks of costae bounding sulcus with a low costa.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|------------------------|--------|-----------------|-------|-----------|
| Holotype | 5.1 | 4.7 | 6.0 ? | 1.7 |
| Paratype (98205) | 5.0 | 4.8 | 3.7 | 2.5 |

Types.—Holotype: 117197a; figured paratypes: 98205, 117197b,c, 117198a,b, 118025; measured paratype: 98205.

Horizon and locality.—Benbolt formation in Virginia: In the road cut on U. S. Highway 19, 1½ miles southeast of Hansonville, Brumley (T.V.A. 205-SE) Quadrangle; Miller Farm on northwest slope of Wallen Ridge, about 2 miles southeast of Ollinger, Ollinger (T.V.A. 178-SE) Quadrangle; ½ mile northwest of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Benbolt? formation in Virginia: 4½ miles southwest of Bland, Bland County.

Edinburg formation (St. Luke facies) in Virginia: On Swover Creek, 4.6 miles N. 69° W. of Edinburg, near Lantz Mills, Edinburg (15') Quadrangle.

Witten formation in Virginia: On Virginia Highway 81, 14 miles southwest of Tazewell, Tazewell (15') Quadrangle; at turn of the road southwest of Jeff Gillespie's on Virginia Highway 88, 14.4 miles west-southwest of Tazewell.

Surgener formation (red beds) in Tennessee: On the roadside 0.3 miles north of the Church at Rose Hill, Maynardville (T.V.A. 145-SE) Quadrangle.

Wardell-Witten (=Dryden) formation in Tennessee: On the east side of Long Branch 1.3 miles northeast of Lone Mountain Station, Tazewell (T.V.A. 154-NE) Quadrangle; Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; bed 41, opposite Thorn Hill store on U. S. Highway 25E, Avondale (T.V.A. 162-SW) Quadrangle; above old marble quarry, ½ mile southeast of Hambright Mine, 8 miles south of Cleveland.

Ward Cove formation ? in Tennessee: Mulberry Gap, 4 miles north-northwest of Sneedville, Back Valley (161-SE) Quadrangle.

Benbolt formation in Virginia: ½ mile southeast of Richpatch, Eagle Rock (15') Quadrangle; on Virginia County Highway 616, 0.6 mile northwest of the junction with County Highway 621, Richpatch, Eagle Rock (15') Quadrangle.

Discussion.—This species is characterized by a short plication in the front part of the sulcus of the pedicle valve and a bifurcation of the median fold of the opposite valve to produce a sulcus in the fold for the accommodation of the median plication. The only other species like this one is *O. elongata*, but that species differs in other respects. It is long and slender and scarcely expanded anteriorly, whereas *O. bifurcata* is fairly broadly triangular and fairly wide anteriorly.

OLIGORHYNCHIA ELONGATA Cooper, new species

Plate 126, A, figures 1-5

Shell small, elongate triangular in outline, compressed in lateral profile; widest at the front; sides nearly straight; apical angle about 40°. Sides flattened. Brachial valve slightly deeper than the pedicle valve. Widest at the front.

Pedicle valve gently convex in lateral profile, marked by 2 strong elevated and subangular costae that bound a deep but narrow sulcus; sulcus occupied by a

single small costa extending not quite to the middle. Flanks marked by 2 costae, 1 strong one depressed below the 2 bounding the sulcus, and a fine costa on the lateral slopes.

Brachial valve more convex than the pedicle valve, marked by a deep and wide median sulcus extending from a point about $\frac{1}{2}$ mm. from the beak to the anterior margin; sulcus occupied by a single angular costa that bifurcates at about the middle of the valve. Flanks marked by 2 costae fairly strong and a third weaker one on the outer slope.

Measurements in mm.—Holotype, length 4.6+, brachial length 4.6, width 3.0, midwidth 2.6, thickness 2.4.

Type.—Holotype: 118016.

Horizon and locality.—Wardell formation (between the *Sowerbyella* and *Hesperorthis* beds) in Tennessee: In the road cut north of Indian Creek on U. S. Highway 25E, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—This species is suggestive of *O. bifurcata* because of the bifurcated costa in the brachial sulcus, but it differs in its more slender form and details of the ornamentation.

OLIGORHYNCHIA INEXPECTATA Cooper, new species

Plate 124, D, figures 24, 25

Shell small for the genus, outline narrowly triangular with the pedicle valve having the greater depth. Sides nearly straight. Valves costate.

Pedicle valve nearly flat in lateral profile but with the umbonal region slightly convex; anterior profile narrowly convex; beak and umbo smooth; umbo and postmedian region carinate; sulcus shallow, narrow and originating at about the valve middle; sulcus bounded by 2 strong subcarinate costae elevated above the flanks and forming a fold; sides marked by 2 oblique, narrow costae.

Brachial valve gently and evenly convex in lateral profile; narrowly convex in anterior profile and with steep, precipitous sides; sulcus narrow at the posterior, originating at the umbo and extending to the anterior margin; sulcus widening strongly at the middle and occupied by a single costa that originates at the middle; flanks narrowly rounded, marked by a bounding strong costa on each side of the fold and 2 finer costae on the sides.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Widest part | Thickness |
|--------------------------------|--------|--------------------|----------|----------------|-----------|
| Holotype (pedicle valve)..... | 3.3 | ? | 1.8 | 2.2 | 1.1 |
| Paratype (brachial valve)..... | ? | 2.7 | 1.8 | 1.8 | 0.7 |

Types.—Holotype: 117203a; figured paratype: 117203b.

Horizon and locality.—Red Knobs formation (between the Athens cobbly beds and the marble) in Tennessee: On the roadside along Hiwassee River, $1\frac{1}{2}$ miles southeast of Charleston, Calhoun (T.V.A. 125-SW) Quadrangle.

Discussion.—This species is characterized by its small and slender form, the short sulcus in the pedicle fold, and the narrow rib in the sulcus of the brachial

valve. This group of characters is unlike that of any other species. In the other described species the sulcus in the pedicle fold originates farther toward the posterior and the costa of the sulcus in the brachial valve is stout and angular rather than slender as in *O. inexpectata*.

OLIGORHYNCHIA SUBPLANA Cooper

Plate 124, B, figures 14-17; plate 124, E, figures 26-31; plate 125, B, figures 16-36;
plate 125, C, figures 37-46; plate 125, D, figures 47-49

Oligorhynchia subplana COOPER, Amer. Journ. Sci., ser. 5, vol. 29, pp. 49-52, pl. 1, figs. 2, 8, 13, 14; text figs. 1-4, 1935.

This species differs from *O. angulata* Cooper in its narrower outline, less angular folds, and its ornamentation.

Types.—Holotype: Y.P.M. S2251; paratypes: Y.P.M. S2253-2257; figured hypotypes: 118014, 117200a,b, 117201a,b, 117202a,b.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: At Luttrell, Luttrell (T.V.A. 155-NW) Quadrangle; 3 to 4½ miles west-southwest of Thorn Hill on the road to Washburn, Avondale (T.V.A. 162-SW) Quadrangle; 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; south side of the school just north of Chesney railroad crossing, Luttrell (T.V.A. 155-NW) Quadrangle; Maynardville Pike, 1.7 miles north-northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; on U. S. Highway 25E, ¾ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; ½ mile southwest of Fleanor Mill, 200 yards north of the highway, Powell Station (T.V.A. 137-SE) Quadrangle; ¾ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle.

Ward Cove formation in Tennessee: ¾ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle.

Sevier formation in Tennessee: ¼ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Lincolnshire formation in Virginia: 33 feet above the base, along the highway beside Tumbling Run, 1½ miles southwest of Strasburg, Strasburg (15') Quadrangle.

OLIGORHYNCHIA SUBPLANA GIBBOSA Cooper

Plate 125, A, figures 1-15; plate 125, E, figure 50

Oligorhynchia subplana gibbosa COOPER, Amer. Journ. Sci., ser. 5, vol. 29, p. 52, pl. 1, figs. 1, 3-5, 12, 1935.

Types.—Holotype: Y.P.M. S2252; figured hypotypes: 90751, 111304.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 3 to 4½ miles west-southwest of Thorn Hill on the road to Washburn, Avondale (T.V.A. 162-SW) Quadrangle; Luttrell, Luttrell (T.V.A. 155-NW) Quadrangle.

OLIGORHYNCHIA sp. 1

Plate 268, I, figures 41-44

A few specimens of *Oligorhynchia* were taken from a limestone 0.7 mile south of Mooney Cemetery on the Bulls Gap (T.V.A. 171-SE) Quadrangle. The horizon represented is either high in the Benbolt or low in the Wardell formations (=Dryden formation where indivisible). It is uncertain which is the correct horizon, but the specimens occur a considerable distance above a sandstone containing *Dinorthis transversa* Willard.

The specimens appear not to belong to *O. bifurcata* because they do not possess the characteristic forking of the median fold in the brachial valve. The specimens are like *O. angulata*, but the fold of the brachial valve seems to be lower and the shell is not so wide anteriorly.

Figured specimen.—118018a.

SPHENOTRETA Cooper, new genus(Greek *sphen*, wedge; *tretos*, opening)

Shell small, triangular to oval in outline, apical angle acute; anterior commissure more or less deeply sulcate; surface costate. Foramen large, longitudinally elliptical or oval; deltidial plates small, triangular, located at the anterior end of the foramen.

Pedicle interior with short divergent dental plates. Other details not determinable in material available.

Brachial valve with divided hinge plate; crural bases small, triangular; crura long and slender, directed obliquely anteriorly and slightly toward the pedicle valve.

Genotype.—*Sphenotreta cuneata* Cooper, new species.

Discussion.—All the material on which this genus is based consists of small specimens, mostly below 5 mm. in length. Generally the shells are filled with crystalline calcite, but the structures are so delicate that they are only visible with difficulty when the shell is removed. The members of this genus have hitherto been placed under *Zygospira*, this association having been inspired by the strong pedicle folding and deep sulcation of the brachial valve which are features of the early spire-bearer. All details of the interior of *Sphenotreta* determined in this work indicate that this genus is a rhynchonellid and not an early spire-bearer. Of the many specimens dissected not one showed any trace of a spire.

This genus is similar to *Oligorhynchia* in external form and interior. The type of folding is similar in the genera except that *Sphenotreta* does not develop a fold in the brachial sulcus. The two genera differ in ornamentation rather strongly. *Oligorhynchia* has a few strong costae only, whereas *Sphenotreta* is wholly costate.

Internally the two genera are similar in having long, slender crura. Further comparison is almost futile because details of the hinge plate of *Sphenotreta* are not yet determined. It is evident, however, from what can be seen, that *Spheno-*

treta had very delicate and small hinge plates which contrast quite strongly with the large structures of *Oligorhynchia*. The pedicle beak structures of the two genera seem to be identical.

One poorly preserved brachial interior shows clearly one of the roles of the brachial sulcus. This deep exterior trough serves as a median ridge in the interior of the valve. The sulcation is so strong and deep that the inner manifestation of this structure appears as a high, narrowly rounded ridge.

Sphenotreta appears first in the Crown Point formation of the Chazy group but extends upward into the Sevier formation. It occurs with *Oligorhynchia* in the latter formation. The genus occurs in crystalline limestones or calcarenites and in soft shale. It is in the former type of matrix in the Lenoir and Sevier formation but occurs in soft shale in the McLish formation of Oklahoma.

SPHENOTRETA ACUTIROSTRIS (Hall)

Plate 124, F, figures 32-38; plate 143, H, figures 37-40

Atrypa acutirostra HALL, Pal. New York, vol. 1, p. 21, pl. 4 bis, fig. 6, 1847.

Rhynchonella acutirostris (HALL), 12th Ann. Rep., New York State Cab. Nat. Hist., p. 65, 1859.

Zygospira acutirostris (Hall) RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 227, pl. 34, figs. 15-22, 1911.

Shell small, triangular in outline with the widest part in the anterior half; posterolateral margins straight, forming an angle of 80°. Anterolateral margins narrowly rounded; anterior margin truncated; anterior commissure sulcate. Surface marked by 10 to 15 narrowly rounded to subangular costae.

Pedicle valve gently and evenly convex in lateral profile; broadly subcarinate in anterior profile. Umbo narrowly convex, marked by a prominent median costa which extends from umbo to anterior margin maintaining its prominent character throughout. Median costa and 1 or 2 on each side form an indistinct fold. Flanks sloping moderately to the margins, not swollen.

Brachial valve gently convex in the median three-fourths but turned in narrowly toward the pedicle valve in the anterior quarter. Anterior profile sulcate, with narrowly convex flanks and precipitous sides. Umbo and median region sulcate; sulcus deep, deepest medially where a narrow groove corresponds to the exaggerated median costa of the pedicle valve. Sulcus occupied by 2 to 4 costae depending on age.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Greatest width | Thickness |
|---------------------------------------|--------|-----------------|----------|----------------|-----------|
| Hypotype (pedicle valve 118019a)..... | 3.7 | ? | 2.7 | 3.4 | 1.0 |
| " (brachial valve 118019b).... | ? | 3.4 | 2.5 | 3.2 | 0.9 |
| " (" " 118019c).... | ? | 3.6 | 2.7 | 3.4 | 0.7 |

Types.—Figured hypotypes: Carnegie Mus. 5439, 5440 (one without number); U.S.N.M. 118015; measured hypotypes: 118019a-c.

Horizon and locality.—Crown Point formation in New York: at Chazy, Rouses Point (15') Quadrangle; Valcour Island, Plattsburg (15') Quadrangle; Crown Point, Port Henry (15') Quadrangle.

Same formation in Vermont: At Isle LaMotte, Rouses Point (15') Quadrangle; near Fort Cassin, Port Henry (15') Quadrangle.

Discussion.—This species is characterized by strong, somewhat distant costae, deep sulcus, and prominent median costa. It is similar to *S. cuneata*, but that species is more deeply sulcate, narrower, and more strongly costate. Its ornamentation is arranged on a different pattern with 5 costae forming the fold.

SPHENOTRETA CUNEATA Cooper, new species

Plate 124, I, figures 46-54

Shell small, elongate triangular in outline; sides nearly straight and forming an apical angle of 65° ; anterolateral extremities narrowly rounded; anterior margin broadly rounded; widest at the front; anterior commissure sulcate; surface with about 12 rounded to subangular costae, 4 of which occupy the sulcus.

Pedicle valve gently convex in lateral profile, broadly convex in anterior profile. Umbonal region narrowly swollen. Median costa larger than all the others and extending from umbo to anterior margin as a high ridge. Median costa with 2 depressed costae on each side forming a fascicle corresponding to the median fold and opposing the 4 costae of the sulcus of the brachial valve. Flanks slightly elevated above the fold but not above the median costa; flanks narrow and marked by about 3 costae.

Brachial valve moderately convex in lateral profile, more convex than the pedicle valve; anterior profile deeply sulcate and with precipitous lateral slopes. Umbo sulcate; sulcus widening and deepening anteriorly to the front margin where it occupies about three-fifths the width. Median slopes long and steep to the bottom of the subangular sulcus, each slope occupied by 2 costae. Flanks narrowly rounded.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Greatest width | Thickness |
|-----------------------------------|--------|-----------------|----------|----------------|-----------|
| Holotype | 3.8 | 3.5 | 2.2 | 2.8 | 1.3 |
| Paratype (pedicle valve 117189b). | 4.8 | ? | 3.3 | 4.3 | 1.2 ? |
| “ (brachial valve 117189c) | ? | 4.5 | 3.0 | 3.9 | ? |
| “ (“ “ 117189d) | ? | 4.6 | 3.6 | 4.8 | 0.9 ? |

Types.—Holotype: 117189a; figured paratypes: 117189b-d,g; unfigured paratypes: 117189e,f.

Horizon and locality.—Sevier formation in Tennessee: Above the old marble quarry $\frac{1}{2}$ mile southeast of Hambright Mine, 8 miles south of Cleveland; 1.3 miles south of the center of Athens, Athens (T.V.A. 125-NE) Quadrangle.

Discussion.—This species is characterized by its strong costae and the great depth and angularity of the sulcus. It is similar to *S. acutirostra* but differs in having the pedicle fold composed of 5 costae rather than 3, in having a deeper sulcus, and a less rounded brachial valve.

SPHENOTRETA SULCATA Cooper, new species

Plate 124, C, figures 18-23

Shell small, triangular in outline and with the maximum width between the middle and the anterior margin; apical angle 70-80°. Anterolateral margins fairly narrowly rounded; anterior margin truncated. Anterior commissure moderately deeply sulcate in the young but nearly rectimarginate in adults. Costate; costae narrowly rounded and closely crowded, 18 or 19 on an adult.

Pedicle valve deeper than the brachial valve and moderately convex in lateral profile and with maximum convexity in the anterior half; anterior profile strongly convex, with the greatest convexity in the middle. Umbonal region flattened. Median region swollen, the swelling forming a narrowly elevated region in the posterior half; front third somewhat flattened and bent in the direction of the brachial valve; flanks gently convex and with steep lateral slopes. Foramen elongate-oval; dental plates short.

Brachial valve more broadly oval than the pedicle valve, less deep and less convex than the pedicle valve. Anterior profile broadly and moderately convex but with median region concave. Umbo sulcate; sulcus moderately deep throughout the valve length. Flanks moderately swollen and with precipitous lateral slopes.

Measurements in mm.—Holotype, length 3.6, brachial length 3.1, midwidth 3.0, greatest width 3.1, thickness 1.4.

Types.—Holotype: 117190a; figured paratype: 117190b; unfigured paratypes: 117190c,d.

Horizon and locality.—McLish formation (bed 45) in Oklahoma: On West Spring Creek, sec. 6, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is characterized by its numerous closely spaced and narrowly rounded costae, a moderately deep sulcus, and oval outline. The species is closest to *S. acutirostris* (Hall) but differs in having a shallower sulcus, more closely spaced costae, and broader outlines. It differs in these same respects from *S. cuneata*.

DORYTRETA Cooper, new genus(Greek *dory*, spear; *tretos*, opening)

Similar to *Sphenotreta* externally but with the sulcus reverting to a fold anteriorly. Foramen elongate oval and with margin thickened; deltidial plates small, triangular.

Pedicle interior with short divergent dental plates. Brachial interior with small triangular socket plates divided by a wide space; crura short, bent abruptly toward the pedicle valve.

Genotype.—*Dorytreta bella* Cooper, new species.

Discussion.—This genus strongly resembles *Hallina*, but no trace of a spire was seen in nearly a dozen specimens prepared to show the interior. Inasmuch as the interiors are filled by translucent calcite, a loop if present should have been detected. The genus resembles *Sphenotreta* but differs in not having the deep

sulcation characteristic of that genus. The brachial valve is sulcate, but the costae in the sulcus rise anteriorly to form a fairly prominent fold. These level off the sulcus and flanks at the front. Inside the brachial valve the parts of the hinge plate are short and delicate but the crura are rather shorter and stouter than those of *Sphenotreta*. Furthermore, the crura extend more directly toward the pedicle valve rather than obliquely forward as they do in *Sphenotreta*.

Dorytreta reversa is placed in this genus with reservations. It is more strongly costate, and the inversion of the sulcus and fold are so exaggerated that some other category may ultimately be required for it.

DORYTRETA BELLA Cooper, new species

Plate 124, G, figures 39-43

Shell small, triangular in outline, widest just anterior to the middle; sides forming an angle of 70° - 80° ; posterolateral margins gently rounded; anterior margin subtruncate. Anterior commissure sulcate in the young, uniplicate in the adult. Surface costate, 16 to 17 costae on an adult.

Pedicle valve deeper than the brachial one, moderately convex in lateral profile and with the greatest convexity at about the middle. Anterior profile moderately and broadly convex. Umbonal region moderately and narrowly convex; median region swollen; median costa more prominent than its fellows on the umbo and median parts; depressed anteriorly with the two on each side of it to form a short and shallow sulcus. Flanks flattened and with moderately steep slopes.

Brachial valve moderately convex in lateral profile, greatest depth slightly anterior to the middle; anterior profile broadly convex but narrowly depressed medially by the sulcus. Umbonal region somewhat flattened. Median region moderately swollen. Sulcus narrow, deepening to middle of valve where it is deepest but rising and becoming a low fold anteriorly. Fold composed of 4 costae, the center 2 depressed slightly below the outer 2. Flanks moderately swollen and with steep sides.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|----------------|--------|-----------------|-------|-----------|
| Holotype | 3.8 | 3.3 | 3.2 | 1.9 |
| Paratype | 4.9 | 4.4 | 4.4 | 2.1 |

Types.—Holotype: 117191a; unfigured paratype: 117191b.

Horizon and locality.—McLish formation (upper part) in Oklahoma: From a roadside ditch in NW $\frac{1}{4}$ sec. 18, T. 2 N., R. 5 E., Pontotoc County.

Discussion.—This species is larger, wider, and more numerously costate than the Tennessee species *D. ovata*.

DORYTRETA OVATA Cooper, new species

Plate 124, A, figures 1-13

Shell small, elongate ovate in outline with the widest part at about the middle; sides rounded; anterior margin somewhat truncate; widest at the middle; apical

angle 80° . Anterior commissure sulcate. Pedicle valve deeper than the brachial one. Costate; costae numbering 10 or 11.

Pedicle valve evenly and moderately convex in lateral profile, broadly convex in anterior profile and with the highest point at the middle to form a subcarinate profile. Umbo not swollen; median costa more elevated than the others and forming a ridge from umbo to front margin; costa on each side of umbo slightly elevated so that the 3 costae form a fold. Flanks flattened and with steep slopes.

Brachial valve gently convex in lateral profile and concave in anterior profile. Sulcus originating on the umbo and extending to the anterior margin; sulcus occupied by 2 costae which rise anteriorly to form an indistinct fold within the sulcus. Flanks moderately swollen.

Measurements in mm.—Holotype, length 2.7, brachial length 2.4, width 2.0, thickness 1.1.

Types.—Holotype: 117192; figured paratypes: 117193a-c; unfigured paratypes: 117193d-f.

Horizon and locality.—Lenoir formation in Tennessee: On the south side of the cemetery at Friends Church, north corner of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; Indian Creek, $1\frac{1}{4}$ miles south of Bluff City, Bluff City (T.V.A. 198-NE) Quadrangle.

Discussion.—This species is characterized by its small size and few costae. It is most like *Dorytreta bella* but is smaller and less numerously costate.

The holotype is not a fully grown specimen because it has not attained maximum thickness or length. All the other specimens besides the figured ones are imperfect. The longest one is about 3.1 mm. in length, and the maximum thickness observed is 1.7 mm.

DORYTRETA ? REVERSA Cooper, new species

Plate 124, J, figures 55-61

Shell small, elongate oval in outline, biconvex but with the pedicle valve slightly deeper than the brachial valve; sides gently rounded; anterior margin subnasute; anterior commissure intraplicate; surface marked by 10 angular costae, 2 in the sulcus, 3 on the fold, and 3 or 4 on the flanks.

Pedicle valve moderately convex and with the posterior and anterior regions more rounded than the median area. Anterior profile broadly convex. Umbonal region somewhat flattened. Fold originating about 2 mm. anterior to the beak, consisting of 3 costae, the outer 2 strongly elevated but the median one depressed in a deep and narrow sulcus in the fold. Flanks flattened and depressed below the fold and with steep lateral slopes. Beak moderately incurved; foramen small.

Brachial valve moderately convex in lateral profile but with a distinct bulge between the umbo and the middle. Gently but broadly convex in anterior profile. Sulcus originating at the umbo, shallow and narrow but widening and deepening anteriorly to occupy about three-fourths the width at the front margin. Sulcus with 2 costae appearing 1 mm. anterior to the beak, these costae strengthen-

ing and becoming elevated anteriorly to form a prominent but narrow fold in the sulcus. Flanks somewhat swollen and with precipitous sides.

Measurements in mm.—Holotype, length 4.9, brachial length 4.4, width 3.9, thickness 2.4.

Type.—Holotype: 117194.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: On the road to Washburn $\frac{3}{8}$ mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Discussion.—The strong costae, fairly large size, and strong inversion of fold and sulcus set this species apart from the other members of this genus.

Family ORTHORHYNCHULIDAE Cooper, new family

Pedicle valve with small interarea; brachial valve with concave crural bases and large cardinal process.

Genus ORTHORHYNCHULA Hall and Clarke, 1893

Orthorhynchula HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 181, 1893.

ORTHORHYNCHULA LINNEYI (James)

Plate 128, F, figures 32-36

Specimens showing the exterior and interior of this genus are introduced for comparison with *Drepanorhyncha* and other rhynchonellids described herein.

Figured specimens.—87042a, 111352.

Superfamily ATRYPACEA Schuchert, 1929

Family ATRYPIDAE Gill, 1871

Spiriferacea with widely divergent crura continuous with the primary lamellae and with the spiral cones between them.

Subfamily ZYGOSPIRINAE Waagen, 1883

Jugum simple, directed either anteriorly or posteriorly and with the spiralia having the apices directed medially.

Genus ZYGOSPIRA Hall, 1862

Zygospira HALL, 15th Rep. New York State Cab. Nat. Hist., p. 154, 1862.—HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 154, 1893.

This is a long-ranging genus which appears chiefly in the upper part of the tier of rocks under consideration in this monograph. In New York and eastern Canada *Zygospira* is reported earliest in rocks of Lowville age, but it is not abundant at this level. In the middle of the overlying Trenton the genus becomes abundant.

In the Southern Appalachians *Zygospira* appears in abundance in the Witten formation and is common or abundant at various levels in the superjacent Ordo-

vician. In the Central Basin of Tennessee it is abundant in the Lebanon and Carters formations. It has not yet been seen in the Simpson group.

From the foregoing it is evident that *Zygospira* has a Wilderness or Trenton age. Rocks in Pennsylvania assigned to the "Chazyan" or "Stones River" and containing *Zygospira* are almost certainly incorrectly dated.

ZYGOSPIRA CIRCULARIS Cooper, new species

Plate 141, C, figures 18-21; plate 142, B, figures 6-10; plate 142, D, figure 16

Shell of about medium size for the genus, nearly circular in outline, without pronounced shoulders; beak obtuse, forming an angle of 110° ; sides and anterior margin rounded. Anterior commissure gently and broadly sulcate. Fold and sulcus not well developed. Costae numbering 22, narrowly rounded and having a width about equal to that of the interspaces.

Pedicle valve strongly convex in lateral profile with the convexity slightly greater in the posterior half. Anterior profile narrowly convex. Umbo narrowly convex; median region somewhat narrowly swollen to form an indistinct fold; flanks slightly concave and with steep slopes to the margins.

Brachial valve with about half the depth of the pedicle valve, moderately and evenly convex in lateral profile, broadly and gently convex in anterior profile; umbonal region slightly convex; sulcus indistinct; flanks somewhat swollen and with moderately steep slopes to the cardinal extremities. Median costa of the brachial valve enlarged and sunk slightly below the level of those surrounding it.

Measurements in mm.—Holotype, length 5.9, brachial length 5.3, width 5.6, thickness 3.7.

Types.—Holotype: III374a; figured paratypes: III385, II7259; unfigured paratype: III374.

Horizon and locality.—Carters formation in Tennessee: Near Franklin, Franklin (15') Quadrangle; on Tennessee Highway 58, 1 mile south of Woodbury, Woodbury (15') Quadrangle; east side of U. S. Highway 70S, 4.2 miles southeast of Nashville; north side U. S. Highway 70S, east of Hill Branch, 1 mile east of Woodbury, Woodbury (15') Quadrangle; north side of U. S. Highway 70S, 0.8 mile east of Readyville, Cannon County.

Top of Lebanon formation: In quarry on U. S. Highway 41, 11.7 miles southeast of Murfreesboro, Rutherford County.

Discussion.—In the possession of an enlarged median rib and corresponding median depression on the pedicle valve this species resembles *Z. variabilis* Fenton and Fenton but differs in its more rounded outline and indistinctness of the fold and sulcus.

ZYGOSPIRA ELONGATA Cooper, new species

Plate 268, G, figures 29-32

Shell of about medium size for the genus, longer than wide, with a subpentagonal outline. Beak obtuse; posterior margins short, connecting the beak with narrowly rounded shoulders and gently rounded lateral margins. Anterior mar-

gin narrow and nearly straight. Anterior commissure narrowly sulcate. Maximum width at about the middle. Surface costate, about 27 costae in all, 5 to 7 costae occupying the sulcus.

Pedicle valve deeper than the brachial valve, fairly strongly convex in lateral profile and with the greatest convexity at about the middle; fold originating at the umbo, narrowly rounded posteriorly but flattened near the anterior margin; sides strongly concave and with steep slopes to the extremities.

Brachial valve moderately and evenly convex in lateral profile and with the maximum convexity located slightly posterior to the middle. Sulcus originating at the umbo, widening and deepening anteriorly to occupy about half the width at the front. Sides bounding sulcus moderately convex; flanks gently convex and with moderate slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|--------------------------|--------|-----------------|-------|-----------|
| Holotype | 5.6 | 5.4 | 5.2 | 3.0 |
| Paratype (111375b) | 6.4 | 5.9 | 5.0 | 3.4 |

Types.—Holotype: 111375a; unfigured paratypes: 111375b-i.

Horizon and locality.—Lebanon formation in Tennessee: Readyville, Cannon County.

Discussion.—This species resembles *Z. lebanonensis* in its form but differs in the possession of more numerous costae, proportionately longer valves, and more costae in the fold and on the sulcus.

ZYGOSPIRA LEBANONENSIS Cooper, new species

Plate 142, C, figures 11-15

Zygospira saffordi Winchell and Schuchert, HALL and CLARKE, Pal. New York, vol. 8, pt. 2, pl. 83, figs. 36-38, 1893.

Shell of about usual size for the genus, subcircular to subpentagonal in outline; length and width about equal; posterior margins straight forming an obtuse angle of 110° with the beak; sides rounded; front margin somewhat truncated to gently rounded. Surface costate, costae numbering 18 to 23 with 5 occupying the sulcus and 4 on the fold.

Pedicle valve moderately and evenly curved in lateral profile with the greatest curvature at about the middle; umbo somewhat carinated; fold strong, extending from the umbo to the front margin, formed of 4 costae about the same level and 2 additional ones on the slope of the fold; flanks moderately concave and with steep slopes to the margins. Beak suberect.

Brachial valve slightly less deep than the pedicle valve, moderately and evenly convex in lateral profile with the greatest convexity at about the center; sulcus originating just anterior to the umbo which is slightly convex, deepening and widening anteriorly where it occupies a little more than half the valve width. The 3 inner costae of the sulcus are depressed below the outer 2, which in turn are slightly depressed below the costae forming the margin of the sulcus. Flanks slightly convex and with moderate slopes to the margins.

Measurements in mm.—Holotype, length 4.5, brachial length 4.1, width 4.5, thickness 2.5.

Types.—Holotype: 111377a; unfigured paratypes: 111377b-f.

Horizon and locality.—Lebanon formation in Tennessee: At Shelbyville, Bedford County; Columbia, Maury County; 3 miles east of Murfreesboro; on U. S. Highway 70S, $\frac{3}{4}$ mile east of Readyville, Cannon County.

Moccasin formation in Tennessee: $\frac{3}{4}$ mile east of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle.

Camp Nelson formation in Kentucky: At High Bridge, Harrodsburg (30') Quadrangle.

Barnhart formation in Missouri: $\frac{3}{4}$ mile north of Riverside, Jefferson County.

ZYGOSPIRA ? MATUTINA Cooper, new species

Plate 141, B, figures 13-17

Shell small, subrhomboidal in outline; greatest width at the middle where prominent shoulders are formed by the union of the posterolateral and anterolateral margins; apical angle about 80° . Anterior commissure strongly and broadly sulcate; surface costellate, costellae subdued and delicate, extending from beak to anterior margin.

Pedicle valve gently convex in lateral profile; narrowly convex in the median region in anterior profile and with long, flat, only moderately steep slopes. Beak long; umbo narrowly convex; median region narrowly convex; anterior region somewhat narrowly folded, and fold moderately elevated and with moderately steep slopes.

Brachial valve gently convex in lateral profile, just perceptibly convex in anterior profile and with a slight depression in the median region. Umbo narrowly sulcate, the sulcus deepening and widening to the anterior margin where it occupies more than half the width. Flanks gently convex. Interior unknown.

Measurements in mm.—Holotype, length 2.4, brachial length 2.2, width 2.3, thickness 0.9.

Type.—Holotype: 117261.

Horizon and locality.—Little Oak formation in Alabama: In the hill east of Leeds, Leeds (15') Quadrangle.

Discussion.—The interior of this interesting little shell is unknown; it was placed in *Zygospira* because its external form and folding are the same as in that genus and its costellae cover the entire surface. In this latter respect it is unlike *Protozyga*. The fine and indistinct costellae differentiate this species from any known *Zygospira*.

ZYGOSPIRA MEDIOCOSTELLATA Cooper, new species

Plate 143, D, figures 13-18

Shell of about usual size for the genus, slightly longer than wide; longitudinally oval in outline; sides rounded; beak forming an angle of 90° . Anterior margin emarginate. Maximum width slightly anterior to the middle. Anterior

commissure strongly sulcate. Surface marked by about 18 or 19 strong costae, 5 in the sulcus and 6 on the fold.

Pedicle valve strongly convex in lateral profile; greatest convexity at or slightly anterior to the middle; anterior profile narrowly convex and with gently convex, steeply sloping sides. Umbo narrowly swollen; median region narrowly swollen to form a prominent fold which is not clearly demarcated from the flanks. Fold marked by a median striation wider and deeper than the others; flanks gently swollen. Beak long and incurved.

Brachial valve gently convex in lateral profile but with the posterior half somewhat flattened and the anterior half moderately convex. Anterior profile broadly sulcate; sulcus broad and shallow, its middle marked by a costa stronger, wider, and more elevated than the surrounding ones, which corresponds to the median striation of the fold of the pedicle valve. Flanks narrowly rounded.

Measurements in mm.—Holotype, length 5.0, brachial length 4.5, width 4.3, thickness 2.6.

Types.—Holotype: 117260a; unfigured paratype: 117260b.

Horizon and locality.—Sevier formation in Tennessee: In wagon road just northwest of the divide, $1\frac{1}{2}$ miles S. 60° W. of Bulls Gap, Mohawk (T.V.A. 172-NE) Quadrangle.

Discussion.—This species is most suggestive of *Z. lebanonensis* but important differences exist. The sulcus of *Z. mediocostellata* is longer, deeper and wider than that of the Lebanon species, and the widest part is posterior to the middle rather than anterior to the middle as in *Z. lebanonensis*. The flanks of the latter shell are more swollen, and the median costella and corresponding striation are less prominent.

ZYGOSPIRA RECURVIROSTRIS (Hall)

Plate 142, H, figures 34-38

Figures of this widely misidentified species are given for comparison with the Appalachian and other species which are mostly older stratigraphically.

Figured specimen.—111389.

Horizon and locality.—Trenton formation in New York: At Martinsburg, Port Leyden (15') Quadrangle.

ZYGOSPIRA VARIABILIS Fenton and Fenton

Plate 142, E, figures 17-25

Zygospira variabilis FENTON and FENTON, Proc. Iowa Acad. Sci. for 1922, vol. 29, p. 75, pl. 2, figs. 7-9, 1924.

Types.—Figured hypotypes: 111387a-c.e.

Horizon and locality.—Plattin group (Macy formation-Zell member) in Missouri: South Beckett Hill, Weingarten (15') Quadrangle.

Discussion.—A silicified specimen in the National Museum collections shows the descending lamellae of the spire and the transverse ribbon in the same position as Hall and Clarke describe it for *Z. modesta* and some forms of *Z. recurvirostra*.

ZYGOSPIRA sp. 1

Plate 186, B, figures 9, 10

Shell of about medium size for the genus, longer than wide, with an elongate oval outline; surface costellate, marked by about 24 narrowly rounded costellae separated by spaces about equal in width to the width of the costellae.

Pedicle valve strongly convex in lateral profile and with the maximum convexity near the middle; anterior profile narrowly rounded and with long concave lateral slopes. Umbonal and median regions narrowly swollen. Fold conspicuous but not clearly demarcated from the flanks. Fold marked in center by a stria wider than the others.

Brachial valve gently convex in lateral profile; anterior profile sulcate; sulcus wide and deep, occupied by 9 costellae, the median one of which is larger than the others and corresponds to the wide striation on the fold of the pedicle valve. Flanks narrowly rounded and inflated.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------------------|--------|-----------------|-------|-----------|
| Hypotype (pedicle valve 117262a)... | 4.2 | ? | 3.1 | 1.0 ? |
| " (brachial valve 117262b)... | ? | 3.4 | 3.3 | 0.6 ? |

*Figured specimens.—*117262a,b.

Horizon and locality.—Gray granular limestone lenses in the Sevier formation in Tennessee: On the hill slope on the west side of the church in Guthrie Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Genus PROTOZYGA Hall and Clarke, 1893

Protozyga HALL and CLARKE, Pal. New York, vol. 8, pt. 2, pp. 149-151, 1893.

Usually small to minute, subcircular to oval in outline, biconvex, with the pedicle valve generally the deeper. Pedicle valve with more or less pronounced fold usually flattened or depressed longitudinally by a narrow sulcus. Brachial valve sulcate and with the sulcus usually occupied by a more or less prominent fold corresponding to the median depression of the fold on the pedicle valve. Flanks smooth or paucicostate. Beak usually incurved, foramen elongate-oval surrounded anteriorly and laterally by deltidial plates. Shell structure impunctate.

Pedicle interior with small teeth buttressed by well-developed dental plates forming a deep delthyrial cavity. Muscle field heart-shaped.

Brachial interior with zygospiroid hinge plate consisting of narrow, triangular socket plates to which the crura are attached. A low median ridge divides the adductor scars but does not extend posteriorly to the hinge plate. Crura very short, terminating in crural processes; descending lamellae long, diverging laterally but converging toward their anterior ends. Spire variable, consisting of part of a volution to nearly a whole volution. The descending branches are united by a stout jugum directed more or less posterodorsally.

Genotype.—*Atrypa exigua* Hall, Pal. New York, vol. 1, p. 141, pl. 33, fig. 6, 1847.

Discussion.—This genus is characterized by its small size, convex valves which are smooth or sparsely costated, and the nature of the interior. The pedicle valve is provided with strong dental lamellae and fairly large teeth, but the chief generic characters appear in the brachial valve. The hinge plate is small and divided, each half forming a small triangular socket or crural plate to which the posterior ends of the crura are attached. The latter are short lamellae terminating in more or less well defined crural processes. The descending lamellae bow outward but then curve inward to the jugum which unites them. The spire itself consists of a varying part of a single volution. The jugum is a stout band and is generally in the form of a more or less pronounced U with the convex base directed posteriorly and toward the brachial valve.

The brachidium of this genus is identical with that of immature *Zygospira*, and the genus was put in the synonymy of that common form. Despite the internal similarities between the two, the exterior characters of *Protozyga* are sufficiently distinct to separate it from *Zygospira*. Moreover, *Protozyga* precedes *Zygospira* in its appearance in the geological column and is undoubtedly ancestral to it.

The type specimens of *Atrypa exigua* Hall on which the name *Protozyga* is based are preserved in the American Museum of Natural History, No. 714/1,2. The lot now consists of 5 specimens, but the original lot, to judge by Hall's figures in Paleontology of New York, vol. 1, consisted of 3 specimens. The type catalog of the American Museum of Natural History, 1898, lists 4 specimens only.

Of the 5 specimens now in the type lot, 1 is a large form, larger than any member of the genus hitherto described, and is evidently the specimen referred to in Whitfield's catalog as coming from Watertown, N. Y. This specimen is figured in Paleontology of New York, vol. 8, pt. 2, pl. 54, figs. 47, 48, and in the Handbook of brachiopods, but it is not figured in the original lot in the Paleontology of New York, vol. 1.

A second specimen consists of a small sliver of calcite containing a fairly well preserved loop. This specimen is not referred to in the catalog. The 3 remaining specimens are well-preserved individuals, 2 of which are alike, but the third, which is squarer and with other differentiating features, differs quite distinctly from the other 2.

In attempting to select one of these specimens to serve as type for the species and incidentally for the genus, too, as the name *Protozyga* is based on the species in question, critical examination of all 5 specimens was undertaken. The calcite sliver can be rejected as a possible holotype because it is impossible to link it with any external form, and the writer was unable to find a jugum in it. The specimen, therefore, does not possess one of the chief defined features of the genus Hall and Clarke were describing. The spire enclosed by the calcite seems to have the features of the brachidium of *Cyclospira*.

The largest specimen which is well preserved would be an ideal type specimen if it conformed to the description and if its internal characters could be demonstrated. Unfortunately, this specimen is shrouded by difficulties. It measures

7½ mm. wide, 6½ mm. long, and 4½ mm. thick. The pedicle valve bears a marked fold that extends from the umbo to the anterior margin. The brachial valve is deeply sulcate but is without a fold in the sulcus as is usual in the zygospiroids under study. The lateral margins are narrowly convex and the anterior margin is excavated medially. The beak is broken off so that the foramen and delthyrial region are not available, although the figures of the specimen reproduced by Hall and Clarke show a small circular foramen which is totally unlike that of any of the zygospiroids in question. The most surprising feature of this specimen is its finely punctate shell. Internally, little can be seen, but the beak is broken off in such a way that dental plates would be revealed if the specimen had had such structures. The form of the specimen, its lack of dental plates, and its punctate shell, as well as its fresh appearance, indicate a specimen far younger in age than any of the zygospiroid stock. The ensemble of characters suggests one of the terebratuloids with fold on the pedicle valve of the Mesozoic such as *Nucleata*, *Pygope*. How such a specimen could be confused with *Atrypa exigua* from New York can only be conjectured, but its equivocal nature excludes it as a holotype for the species. The remaining three specimens are available for choosing a lectotype. Of these three, the one from Watertown, New York, is rejected as not belonging in the original lot. Of the remaining two, one is immature and without costae, the other is imperfect, having a small sliver out of one side. This specimen is adult in size and exhibits the costae faintly. It is therefore selected as type of the species.

Protozyga is a fairly common genus in the rocks covered by this monograph. It occurs first in the Crown Point limestone from which a single specimen is known. This specimen is an elongate form with prominent attenuate beak and a few obscure costae on the margins. The interior of this specimen is unknown, but it is the earliest brachiopod like *Protozyga* to be seen.

In the Southern Appalachians the genus appears first in the Whistle Creek formation, but the three specimens taken do not yield information on the interior. These specimens are not folded like the later ones, which might be a natural characteristic of one of the earliest members of the genus.

Specimens are locally abundant in the Ward Cove limestone and the Benbolt and Wardell formations. In these the tendency to folding is more highly developed, but this reaches its maximum development in Trenton species. The Rockland formation yields *P. exigua* which is strongly folded and fairly strongly costate. The folding reaches its maximum in *P. profunda*.

PROTOZYGA COSTATA Cooper, new species

Plate 142, A, figures 1-5

Small, oval in outline with the length greater than the width; widest at the middle; valves unequal, the pedicle valve having a greater depth than the brachial valve; apical angle 100°; sides rounded; anterior margin rounded to subnasute; anterior commissure faintly sulcate; surface paucicostate, 2 costae in the sulcus (rarely 3), 3 costae on the fold (rarely 4), and 4 costae on the flanks; costae usually not extending for more than two-thirds the length from the margin.

Pedicle valve strongly convex in lateral profile with the maximum convexity in the posterior half; anterior commissure somewhat narrowly convex and with long, steep lateral slopes. Umbo narrowly convex; median region narrowly inflated; anterior third marked by a low, poorly defined fold.

Brachial valve shallow, gently convex in lateral profile; anterior profile barely concave to broadly and gently convex; umbonal region broadly and gently convex; sulcus narrow and shallow, originating near the middle and almost completely filled by 2 costae. Sulcus shallow throughout its length. Flanks gently inflated. Spire as described for the genus.

Measurements in mm.—Holotype, length 4.5, width 3.9, thickness 2.2.

Types.—Holotype: 117239c; unfigured paratypes: 117239a,b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: In the road cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County; on the north side of Falls Creek along the road to the Baptist Camp, NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 32, T. 1 S., R. 2 E., Murray County; from deep well at 3,240 to 3,244 feet in Mid-continent Petroleum Corporation well, sec. 22, T. 4 N., R. 3 E., Pottawatomie County.

Discussion.—This species is characterized by its strong costae and elongate form. In the latter respect it is like *P. elongata*, but that species is not so strongly costate. It differs from other Oklahoma species and the known species outside of Oklahoma by the moderate development of the fold and sulcus and the strong costation of these features.

PROTOZYGA ELONGATA Cooper, new species

Plate 140, E, figures 27-37; plate 143, I, figures 41-46

Shell small, elongate oval in outline with the greatest width at about the middle; sides gently rounded; anterior margin truncated. Surface marked by fine growth lines and the flanks by 2 to 4 obscure costae.

Pedicle valve fairly strongly convex and with the greatest convexity at about the middle; beak elongated; umbo narrowly rounded and extended anteriorly as a prominent fold to the anterior quarter where a shallow sulcus divides the fold into 2 narrowly rounded costae. Flanks concave and steep sided. Marginal fold between umbo and shoulder fairly strong.

Brachial valve with less depth and less convexity than the pedicle valve and with the maximum convexity at about the middle. Umbonal and median regions somewhat swollen. Fold narrow, originating at about two-thirds the length from the beak of the brachial valve. Flanks convex but with moderate slopes to the extremities.

Measurements in mm.—Holotype, length 3.1, width 2.3, thickness 1.7.

Types.—Holotype: 117241a; figured paratypes: 117241b,c, 111408a,b.

Horizon and locality.—Bromide formation (Mountain Lake member—*Doleroides* zone=bryozoan zone) in Oklahoma: Along the old road up the hill northwest of the old Galbraith Hotel, sec. 32, T. 1 S., R. 8 E., Johnston County;

ditch on east side of road 2,300 feet south and 2,000 feet west of the northeast corner of sec. 36, T. 1 S., R. 7 E., 1 mile west of Dolese Brothers Crusher, Bromide, Johnston County; zone 36, on Oklahoma Highway 99, SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, T. 1 N., R. 6 E., Pontotoc County; *Mimella* zone, Baptist grounds at Falls Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 1 S., R. 2 E., Murray County; bed 2, west of Nebo store, sec. 22, T. 2 S., R. 3 E., Murray County; road cut on east side of section line road, 1,300 feet south of the northwest corner of sec. 23, T. 1 S., R. 3 E., opposite road to abandoned town of Gilsonite, Murray County; 50 to 75 feet below ford of Hickory Creek, 2 miles west of Overbrook, Carter County; 2 miles northeast of Springer, McLish Ranch, sec. 24, T. 1 S., R. 7 E., Johnston County.

Discussion.—This species is characterized by its elongate form and the elongation of the beak which is not strongly incurved. In this respect it resembles *P. superba*, but that species is larger, wider, and more deeply sulcate than *P. elongata*. Confusion with *P. loeblichii* is not likely to occur because that species is wider and with a much less elongated beak.

Protozyga elongata is a variable species as are all members of this genus. The variation takes form in more convex or somewhat wider individuals with a less elongated beak. If found by themselves, some of these might be assigned to other species.

PROTOZYGA EXIGUA (Hall)

Plate 119, D, figures 9-14; plate 140, F, figures 38-42; plate 142, G, figures 29-33

Atrypa exigua (HALL), Pal. New York, vol. 1, p. 141, pl. 33, fig. 6, 1847.—EMMONS, Amer. geology, vol. 1, pt. 2, p. 190, pl. 10, fig. 6, 1855.—LESLEY, Pennsylvania Geol. Surv., Rep. P. 4, p. 55, 1889.

Genus ? *exigua* HALL, 12th Rep. New York State Cab. Nat. Hist., p. 66, 1859.

Protozyga exigua (Hall) HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 149, figs. 137, 138 (not pl. 54, figs. 47, 48), 1893.

Zygospira exigua (Hall) SCHUCHERT, U. S. Geol. Surv. Bull. 87, p. 463, 1897.

Large for the genus, pentagonal in outline; strongly inequivalve; postero-lateral margins nearly straight, forming an apical angle of about 100°. Greatest width at or near the middle. Sides narrowly rounded. Anterior margin broadly rounded. Anterior commissure broadly sulcate. Surface paucicostate, about 5 obscure costae on the flanks, fold and sulcus variably costate.

Pedicle valve strongly convex in lateral profile and with the maximum convexity at about the middle; anterior profile narrowly convex in the middle and with depressed and concave sides. Umbonal region narrowly convex, continued anteriorly as a strong, steep-sided fold which is flattened on top and often with a slight depression. Fold with 2 or 3 obscure costae. Flanks concave but with lateral areas deflected slightly in the direction of the pedicle valve.

Brachial valve moderately convex in lateral profile; maximum convexity at about the middle; anterior profile gently and broadly convex but with a narrow and shallow median depression. Umbo sulcate; sulcus shallow throughout its length from umbo to anterior margin; fold in sulcus originating anterior to

middle when present, usually low and obscure but more frequently not developed. Flanks inflated and with steep lateral slopes. Median ridge moderately strongly developed.

Measurements in mm.—

| | | Length | Width | Thickness |
|----------|----------------|--------|-------|-----------|
| Hypotype | (117242a)..... | 6.4 | 6.6 | 4.6 |
| " | (117242b)..... | 6.5 | 6.2 | 4.2 |
| " | (117242c)..... | 6.6 | 6.4 | 4.3 |
| " | (123298a)..... | 6.7 | 6.0 | 4.2 |
| " | (123298b)..... | 5.8 | 6.0 | 3.7 |

Types.—Lectotype: A.M.N.H. 714/1,2a, large imperfect specimen; paratype: 714/1,2b, small perfect specimen; figured hypotype: 117242e; measured hypotypes: 117242a-c, 123298a,b.

Horizon and locality.—Rockland formation (Napanee member) in New York: Just west of the bridge over Mill Creek in the city of Lowville, Lowville (15') Quadrangle; on the west side of New York Highway 12 at its crossing of Sugar River, about 4 miles south of Port Leyden, Port Leyden (15') Quadrangle.

Discussion.—This species is recognized by its large size, shallow sulcus, and moderately strong costae on the margins. It resembles *P. profunda* Cooper but differs in having a less deep sulcus and a less narrow fold. It also suggests *P. nicolleti* but differs in not having a strong sulcus in the fold of the pedicle valve and in not having the strong development of the fold within the sulcus, which is so prominent in the Minnesota species. It is also close to *P. superba*, but that species has a short but prominent fold in its sulcus. The Missouri species also has fuller and more convex flanks. See discussion of genus above for selection of type specimen.

PROTOZYGA LOEBLICI Cooper, new species

Plate 140, C, figures 17-21

Shell small, subpentagonal to longitudinally elliptical in outline; beak obtuse; sides broadly rounded; anterior margin subnasute. Surface smooth in the posterior two-thirds, marked on the margins by obscure costae, 1 or 2 of which appear on the flanks.

Pedicle valve evenly and gently convex in lateral profile and with the greatest convexity located at about the middle. Beak incurved but not resting on the umbo of the brachial valve which is gently convex; median region inflated; sulcus bounded by 2 narrowly rounded costae, sulcus originating at about the middle and extending to the anterior margin; flanks concave and with steep slopes.

Brachial valve moderately and evenly convex in lateral profile and with the maximum curvature near the middle. Anterior profile broadly convex. Umbonal region gently convex, median portion of valve somewhat inflated. Fold originating in the anterior third, low and narrow, flattened on top and set off by 2 oblique, shallow grooves. Flanks convex and with moderate slopes.

Measurements in mm.—

| | Length | Width | Thickness |
|----------------|--------|-------|-----------|
| Holotype | 3.1 | 2.7 | 1.7 |
| Paratype | 3.1 | 2.6 | 1.8 |

Types.—Holotype: 111412a; unfigured paratype: 111412b.

Horizon and locality.—Bromide formation (Pooleville member—*Oxoplectra gouldi* zone) in Carter County, Okla.: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills.

In Murray County, Okla.: At the top of Bromide, small quarry east of road in center NW $\frac{1}{4}$ sec. 11, T. 11 S., R. 3 E.; middle of bed 2, Spring Creek, sec. 17, T. 2 S., R. 1 W.; slightly north of the middle of sec. 32, T. 2 S., R. 2 E., 2 to 3 miles northeast of Springer; 50 feet below the Viola, 4 miles west and 2 miles south of Davis.

Discussion.—This species is suggestive of *P. nicolleti* and also of *P. rotunda*. From the former it differs in not possessing the strong radial costae on the flanks and in having a much broader fold in the sulcus of the brachial valve. It differs from *P. rotunda* in its smaller size, less rotund profile, less circular outline, more prominently elevated fold of the brachial valve, and the anterior third less deflected toward the pedicle valve. The front margin of *P. loeblichii* is less nasute than that of the Tennessee species and is generally sharply truncated anteriorly.

PROTOZYGA MAGNICOSTATA Cooper, new species

Plate 140, A, figures 1-9

Shell resembling *P. costata* but length and width nearly equal; widest at or near the middle; sides strongly rounded; anterior margin somewhat broadly rounded; anterior commissure faintly sulcate; surface paucicostate, 2 strong costae marking the sulcus, 3 on the fold, and 2 or 3 on the flanks. Median costa of fold usually depressed and corresponding with furrow between costae occupying sulcus. Costae strong.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 4.0 | 3.9 | 2.2 |
| Paratype (117245b) | 4.1 | 3.9 | 2.0 |

Types.—Holotype: 117245a; figured paratypes: 117245b, 118040.

Horizon and locality.—Bromide formation (Mountain Lake member—30 to 34 feet below the top of bed 10) in Oklahoma: On Tulip Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County; bed 7, Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species suggests *P. costata* but differs in being more rotund in outline and having stronger, more sparsely placed costae. Furthermore, *P. magnicostata* differs in the arrangement of the costae on the fold of the pedicle valve, the median one of which is sunk below the bounding, outside 2.

PROTOZYGA MICROSCOPICA Cooper, new species

Plate 141, D, figures 22-24; plate 141, F, figures 33-37

Shell minute, subpentagonal in outline; sides gently rounded; anterior margin truncated; posterolateral margins straight, forming an apical angle of about 100° . Surface smooth, except for a short fold on the brachial valve and 2 obscure costae on the pedicle valve.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity slightly posterior to the middle; anterior profile narrowly convex in the median region but with concave lateral slopes. Umbo narrowly rounded; median region swollen narrowly to form an indistinct fold which is marked medially by a deep sulcus originating about one-third the length from the anterior margin. Sulcus bounded by short, narrow costae. Flanks gently concave.

Brachial valve gently convex in lateral and anterior profiles; umbonal and posteromedian areas swollen; sulcus broad and shallow, originating at about one-third the length from the anterior margin, occupied almost completely by a low, rounded fold corresponding to the sulcus of the pedicle valve; fold separated from the flanks by short, narrow grooves. Flanks gently inflated.

Measurements in mm.—

| | Length | Width | Thickness |
|----------------|--------|-------|-----------|
| Holotype | 3.3 | 2.9 | 2.0 |
| Paratype | 2.2 | 1.9 | 1.3 |

Types.—Holotype: 117243; figured paratype: 117244.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: $\frac{3}{8}$ mile east-northeast of Red Hill, about 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; 3 miles west-southwest of Thorn Hill, same quadrangle; Luttrell, Luttrell (T.V.A. 155-NW) Quadrangle.

Ward Cove formation in Tennessee: At Evans Ferry; in Mulberry Gap 4 miles north-northwest of Sneedville, Back Valley (T.V.A. 161-SE) Quadrangle.

Ward Cove formation in Virginia: On Virginia Highway 82, $1\frac{1}{4}$ miles northwest of Lebanon, Lebanon (T.V.A. 205-NE) Quadrangle.

Elway formation in Tennessee: At Marble Bluff, 8 miles west-northwest of Loudon, Loudon (30') Quadrangle.

Discussion.—This species is characterized by its convex valves and the subdued nature of the folding of both valves and the margins. *Protozyga microscopica* has a less prominent beak than *P. nasuta*, which it resembles in contour, and is also more prominently sulcate in the pedicle valve than that species. *Protozyga loeblichii* has a less prominent fold than *P. microscopica* and lacks costae on the margins. *Protozyga rotunda* is a larger and more robust shell which is more strongly costate than *P. microscopica*.

PROTOZYGA NASUTA Cooper, new species

Plate 141, G, figures 38-41

Small for the genus, subpentagonal in outline; lateral margins gently rounded; anterior margin gently rounded; anterior commissure nearly rectimarginate; surface smooth and without visible costae.

Pedicle valve moderately convex in lateral profile and with the maximum convexity at about the middle; anterior profile somewhat narrowed; median region somewhat narrowed but becoming flattened and faintly depressed in the anterior third. Beak long, narrow, incurved, Flanks faintly convex.

Brachial valve only slightly less deep than the pedicle valve, fairly strongly convex in lateral profile and with the maximum convexity just posterior to the middle; anterior profile broadly and moderately convex; region just posterior to middle strongly inflated; umbo swollen; anterior half flattened; flanks not differentiated from the median region, gently convex but with gentle slopes.

Measurements in mm.—Holotype, length 2.8, width 2.5, thickness 1.6.

Types.—Holotype: 117246a; unfigured paratypes: 117246b-i.

Horizon and locality.—Whistle Creek formation in Virginia: On U. S. Highway 60, 100 yards southeast of Whistle Creek, 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species is characterized by its long beak, lack of folding, and absence of well-marked fold and sulcus. It differs from *P. rotunda* and *P. microscopica*, which it resembles in its strong convexity, by its general lack of folding.

PROTOZYGA NICOLLETI (Winchell and Schuchert)

Plate 141, J, figures 51-57

Hallina nicolleti WINCHELL and SCHUCHERT, Amer. Geol., vol. 9, p. 293, Apr. 1, 1892; Geol. Minnesota, vol. 3, p. 474, pl. 34, figs. 59-64, 1895.

Zygospira aquila SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 335, pl. 4, figs. 15-18, Apr. 9, 1892.

Z. nicolleti Winchell and Schuchert, BEECHER and SCHUCHERT, Proc. Biol. Soc. Washington, vol. 8, pt. 2, p. 71, pl. 10, fig. 23, 1893.

This is one of the largest of the known species of the genus and can be recognized by its strongly incurved beak, strongly elevated fold of the pedicle valve with narrow sulcus, strongly incurved beak, narrow brachial fold in a wide, shallow sulcus, and the strong and numerous costae marking the flanks. A large specimen measures 5.4 mm. in length, 5 mm. in width, and 3 mm. in thickness.

The species differs from *P. rotunda* by its stronger costation and more prominent fold on the brachial valve. It differs from *P. superba* by its shallower sulcus, less pronounced fold on the pedicle valve and stronger fold on the brachial valve, combined with the less prominent beak.

Types.—Figured hypotypes: 24201a, 49060a.

Horizon and locality.—Platteville formation in Minnesota: At St. Charles, Winona County; Rochester, Elmira, and NW $\frac{1}{4}$ sec. 10, Olmstead County; Minneapolis.

Platteville formation (MacGregor member): On Minnesota Highway 74, just east of Chatfield; U. S. Highway 52, 2 to 3 miles north of Fountain, Fillmore County.

In Illinois: 1 $\frac{1}{2}$ miles northeast of Dixon, Dixon (15') Quadrangle.

Same formation in Wisconsin: Road cut near Dickeyville, sec. 9, T. 2 N.,

R. 2 W., Grant County; quarry on Wisconsin Highway 81, 1 mile northwest of Ellenboro, Lancaster (30') Quadrangle.

PROTOZYGA PROFUNDA Cooper, new species

Plate 143, A, figures 1-6

Shell large for the genus, slightly wider than long, outline pentagonal. Strongly inequivalved; posterolateral margins nearly straight, forming an angle of about 110° ; sides narrowly rounded and with the greatest thickness at about the middle; anterior somewhat truncated; anterior commissure strongly sulcate; surface paucicostate, flanks with as many as 7 more or less distinct fine costae not reaching the beak; fold and sulcus finely but variably costate.

Pedicle valve strongly convex in lateral profile, with the maximum curvature in the posteromedian part; anterior profile with narrowly convex middle part and concave flanks; umbo narrowly swollen and continued anteriorly as a steep and narrow fold; sulcus in fold originating at about the middle, shallow and narrow. Flanks deeply concave but with flattened sides.

Brachial valve moderately convex in lateral profile and with the maximum convexity at about the middle; anterior profile broadly convex but with a median, deep sulcus; umbo sulcate, the sulcus continued anteriorly and forming a deep and narrow trench; tongue long and narrow; flanks bounding sulcus somewhat narrowly swollen and with steep lateral slopes. Interior as in the genus.

Measurements in mm.—Holotype, length 5.8, width 6.6, thickness 4.0.

Types.—Holotype: 117247a; unfigured paratype: 117247b.

Horizon and locality.—Trenton formation in Quebec: In a quarry near St. Francis de Salle, Montreal.

Discussion.—This species differs from all others here assigned to *Protozyga* by the great depth of its sulcus and the nearly complete costation of the flanks.

PROTOZYGA ROTUNDA Cooper, new species

Plate 140, B, figures 10-16; plate 140, H, figures 48-52; plate 140, I, figures 53-58

Shell small, nearly circular in outline, strongly biconvex, beak approximately a right angle or slightly obtuse, sides strongly rounded, anterior margin protruding slightly, rounded. Surface smooth or with 1 or 2 short, obscure costae on the margins of the flanks near the fold or sulcus.

Pedicle valve generally deeper than the brachial valve, strongly convex and with the greatest convexity at about the middle; beak strongly incurved and in old specimens closely pressed down on the umbo of the brachial valve; umbonal region gently convex in profile, narrowly convex in anterior view; fold originating on the umbo, not strongly elevated and extending to the anterior margin. Sulcus shallow; appearing in the fold a short distance posterior to the anterior margin; flanks gently convex or nearly flat in profile and with steep slopes to the margin. Beak ridges short, not prominent.

Brachial valve moderately to strongly convex depending on age, the older shells more rotund and deeper; anterior profile moderately convex. Umbonal

region gently swollen and the median region slightly more inflated. Sulcus shallow, originating about one-third the length from the anterior margin, occupied by a low fold. Flanks moderately convex, and with moderately steep slopes to the margins.

Interior: Spire long, with long descending branches and a wide jugum extending nearly horizontally between the descending branches at about the middle of the valve. Hinge plates triangular, small.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------|--------|-------|-----------|
| Holotype | 4.9 | 4.7 | 3.4 |
| Paratype (111435a)..... | 4.0 | 3.7 | 2.7 |
| “ (117248a)..... | 4.2 | 3.5 | 2.6 |
| “ (117248b)..... | 4.0 | 3.6 | 2.5 |

Types.—Holotype: 111433a; figured paratypes: 111435a-c, 111433b, 117248b; measured paratype: 117248a.

Horizon and locality.—Wardell formation and Wardell part of the Dryden formation (*Hesperorthis* beds) in Tennessee: 0.3 mile southwest of Little Baren Church, on old Tennessee Highway 33, 10 miles southwest of Tazewell in Powder Springs (T.V.A. 154-SW) Quadrangle; vicinity of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; west side of the sharp loop on the road down Flint Creek, NW $\frac{1}{4}$ of the center subquad., Powder Springs (T.V.A. 154-SW) Quadrangle; north of the Canyon of Gap Creek, Powell Valley, Tennessee grid 790250N, 2677730E, 1 $\frac{1}{4}$ miles west of Arthur, Cumberland Gap (T.V.A. 153-SW) Quadrangle; 3 $\frac{1}{2}$ miles north of Ooltewah, Ooltewah (T.V.A. 112-SE) Quadrangle; Evans Ferry, $\frac{1}{2}$ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Wardell formation in Virginia: At Lloyd Carter's barn, 0.8 mile northeast of Rye Cove School, Clinchport (T.V.A. 188-NW) Quadrangle; quarry on Station Creek, $\frac{1}{2}$ mile south of U. S. Highway 58, 2 miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle.

Ridley formation in Georgia: On U. S. Highway 27, 1 mile north of Rock Spring, Nickajack Gap (T.V.A. 113-SW) Quadrangle; quarry on the west side of the road 1 $\frac{1}{2}$ miles south-southeast of Cove Church, 5 miles south of Chickamauga, Kensington (T.V.A. 106-SE) Quadrangle.

Ridley formation in Tennessee: 1 $\frac{1}{2}$ miles southeast of Hembree Mill, Sequatchie Valley, Pikeville Special (15') Quadrangle.

Lebanon formation in Tennessee: On U. S. Highway 70N opposite Fairview Service Station, $\frac{1}{2}$ mile west of Rome, Smith County.

Barnhart formation in Missouri: On the old road 1 mile north of Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E., Weingarten (15') Quadrangle.

Discussion.—Silicified specimens from the "Lowville" limestone of Georgia permit description and illustration of some features of the interior. The dental plates are well developed, flaring and extended along the side of the muscle field for a short distance. The teeth are moderately strong and have well-developed

sockets between the tooth proper and its attachment to the valve. The individual muscle marks of this valve are not visible but the field is somewhat heart-shaped, large, and located just anterior to the delthyrial cavity.

The hinge plate of the brachial valve is zygospiroid; divided into two oblique socket plates, short and narrow, that are attached to the valve on the sides of the notothyrial cavity. The adductor scars are small, and arranged on each side of a low median ridge that does not reach posteriorly to the notothyrial cavity and does not support the hinge plate.

This species is characterized by its globular form and fairly large size. It differs from *P. nasuta* and *P. microscopica* in size and in having more prominent folding and costation. It resembles *P. loeblichii* but is a larger shell with more circular outline, less prominently elevated fold on the brachial valve, and the anterior third more deflected toward the pedicle valve.

PROTOZYGA ROTUNDIFORMIS Cooper, new species

Plate 140, J, figures 59-62

Shell nearly circular in outline, slightly longer than wide; sides rounded, anterior margin truncated; valves subequal, the pedicle valve having the greater depth; paucicostate, the flanks marked by 1 or 2 obscure costae confined to the anterior and lateral margins.

Pedicle valve moderately and evenly convex in lateral profile and with the maximum convexity at the middle; anterior profile strongly convex and with moderate slopes. Median region inflated; umbonal region narrowly rounded, the rounding continued anteriorly but indistinctly as a low fold. Fold sulcate in anterior third, sulcus short, moderately deep, defined by a short costa on each side. Flanks gently inflated and with moderately steep slopes to the margins.

Brachial valve moderately convex in lateral profile, maximum convexity just posterior to the middle; anterior profile broadly but fairly strongly convex; median region strongly swollen; sulcus originating just anterior to the middle, poorly defined and indistinct; sulcus occupied by a poorly defined low fold indistinct except at the margin. Flanks swollen and steep-sided.

Measurements in mm.—Holotype, length 2.9, width 2.5, thickness 2.0.

Type.—Holotype: 117249.

Horizon and locality.—Lincolnshire formation (90 to 120 feet above the "Mosheim") in Tennessee: On U. S. Highway 25E, 1 mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—This species is characterized by its small size and globular form. It is much smaller than *P. rotunda* and differs further from that species in its more circular outline, stronger marginal costae, and the more nearly equal depth of its valves. The stronger costation distinguishes this species from *P. nasuta* and *P. microscopica*, both of which occur in formations near the age of that of *P. rotundiformis*.

PROTOZYGA SUPERBA Cooper, new species

Plate 141, L, figures 63-69

Zygospira nicolleti Winchell and Schuchert, FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 19, No. 3, p. 199, pl. 23, figs. 8A, 8B, 1920.

Adult fairly large for the genus, pentagonal to subcircular in outline; beak acute to obtuse, strongly incurved; lateral margins rounded; anterior margin narrowly rounded to subtruncate. Surface smooth except for 2 or 3 costae developed along the front margin on each side of the fold and sulcus.

Pedicle valve with nearly twice the depth of the brachial valve, strongly convex in lateral profile with the greatest convexity in the posterior half in the adult; umbo narrowly swollen; fold originating on the umbo and extending as a rounded plica to the middle of the valve where a shallow depression develops in the center of the fold and extends to the front margin; flanks nearly flat in profile and with steep slopes to the margins.

Brachial valve evenly and moderately convex in lateral profile with the greatest convexity at about the middle; umbonal, median region, and flanks somewhat swollen; sulcus originating on the umbo, where it is poorly defined and shallow, becoming deeper and wider near the middle and occupying nearly half the width at the front margin. One or two costae appearing anteriorly in the sulcus which correspond to the sulcus in the fold of the pedicle valve; sulcus drawn anteriorly and toward the pedicle valve into a moderately long, squarely truncated tongue. Flanks convex in profile and slopes to the margins moderately steep.

Interior: Dental plates of pedicle valve well developed; adductor muscle tracks of brachial valve long and slender.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------|--------|-------|-----------|
| Holotype | 5.3 | 4.9 | 3.4 |
| Paratype (111455b)..... | 4.1 | 4.2 | 2.8 |
| “ (111455c)..... | 4.6 | 4.5 | 3.2 |

Types.—Holotype: 111455a; unfigured paratypes: 111455b,c.

Horizon and locality.—Auburn chert in Missouri: $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle.

Top of Platin group (=Barnhart formation) in Missouri: Buford Cave, Ralls County; Yeager Farm, south edge of Ralls County; Conns Ford, Ralls County.

Discussion.—This species resembles *P. nicolleti* but differs in possessing a more convex pedicle valve, fewer costae on the flanks, a deeper sulcus, and a lesser development of the fold within the sulcus of the brachial valve. This latter feature is the most striking difference. In the Minnesota species the fold may originate in the sulcus posterior to the middle of the valve, but in *P. superba* the fold within the sulcus occurs in the front part of the sulcus and on the tongue.

PROTOZYGA TUMIDA Cooper, new species

Plate 140, G, figures 43-47; plate 141, I, figures 46-50

Shell of about medium size for the genus, length and width nearly equal; sub-pentagonal in outline; apical angle about 120° . Surface paucicostate, 4 or 5 obscure costae on the flanks.

Pedicle valve fairly strongly convex in lateral profile, and with the maximum convexity at about the middle; anterior profile narrowly convex in the median region and with steeply sloping sides. Umbonal region narrowly convex and continued anteriorly as an indistinct fold; fold prominent in the anterior third and marked by a deep and wide sulcus originating at about one-third the length from the anterior margin; flanks flat to gently concave and with steep slopes.

Brachial valve shallow, gently convex in lateral profile and with the maximum curvature slightly posterior to the middle; anterior profile gently convex to nearly flat; umbonal and median regions swollen; sulcus originating just anterior to the middle, broad and shallow; sulcus occupied by a narrow, rounded fold equal in length to about one-third the valve length. Sulci bounding fold fairly wide and moderately deep. Flanks gently inflated and with gentle slopes.

Measurements in mm.—

| | Length | Width | Thickness |
|----------------|--------|-------|-----------|
| Holotype | 3.5 | 3.2 | 1.9 |
| Paratype | 3.0 | 2.9 | 1.6 |

Types.—Holotype: III1440; figured paratype: III1400.

Horizon and locality.—Effna formation in Virginia: At McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; equivalent of Effna formation 4 and 6 miles southwest of Bland, Bland County.

Discussion.—This species is characterized by its strongly pentagonal form and the broad, shallow brachial valve. The low convexity of this valve distinguishes the species from all the others herein described.

PROTOZYGA UNIPLICATA Cooper, new species

Plate 140, D, figures 22-26; plate 141, H, figures 42-45; plate 141, K, figures 58-62

Shell small, longer than wide, heptagonal in outline; sides broadly rounded; apical angle 100° ; surface smooth except for 1 or 2 obscure costae on the flanks.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity at about the middle; anterior profile narrowly convex but with long, steep, flat slopes. Umbonal region narrowly inflated; median region narrowly rounded, the rounding forming a fairly prominent but low fold at the anterior; fold fairly deeply but narrowly sulcate in its anterior quarter to third. Sides steep and flat. Beak erect.

Brachial valve gently convex in lateral profile and with the greatest convexity at the middle; anterior profile moderately rounded; umbonal and median regions somewhat inflated; sulcus originating at about the anterior third and occupied by a prominent fold separated from the flanks by 2 narrow and moderately deep depressions. Flanks swollen and steep.

Measurements in mm.—

| | Length | Width | Thickness |
|-------------------------|--------|-------|-----------|
| Paratype (117250a)..... | 3.4 | 2.8 | 1.8 |
| " (111416a)..... | 3.6 | 3.0 | 1.7 |

Types.—Holotype: 111416b; figured paratypes: 111414a,c, 111416a; unfigured paratypes: 111414b, 117250a.

Horizon and locality.—Benbolt formation in Virginia: At Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, 1½ miles due south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; north side of U. S. Highway 19, about 1 mile due north of Belfast Mills, Saltville (T.V.A. 212-NE) Quadrangle.

Benbolt formation in Powell Station (T.V.A. 137-SE) Quadrangle, Tennessee: 1.6 miles northeast of Heiskell; road corner ½ mile southeast of Fleanor Mill.

Murfreesboro formation (top) in Tennessee: On the west fork of Stone River at its junction with U. S. Highway 70S, 1½ miles northwest of Murfreesboro, Murfreesboro (15') Quadrangle.

Discussion.—*Protozyga uniplicata* may be recognized by its elongate form, short beak, and prominent anterior folding. It differs from *P. microscopica* in its narrower form and less convexity; from *P. elongata* it differs in its much shorter beak. It is much less rotund and convex than *P. rotunda*.

PROTOZYGA sp. 1

Plate 142, J, figures 44-48

Shell of about usual size for the genus, longer than wide; oval to subpentagonal in outline; posterolateral margins forming an angle of about 90°. Lateral margin broadly rounded; anterior margin narrowly rounded. Surface marked by short costae at the margins, 3 or 4 on each side.

Pedicle valve moderately convex in lateral profile and with the maximum convexity at the umbo or just anterior to it; anterior profile narrowly convex and with steep sides; umbo and median region forming a subcarinate fold which extends to the anterior margin; fold marked by a shallow sulcus beginning at about the middle of the valve and extending to the anterior margin; sulcus in fold marked by a single costa extending the length of the sulcus; flanks nearly flat and very steep.

Brachial valve gently convex in lateral profile and with the maximum convexity just anterior to the umbo; anterior profile broadly convex but marked by a narrow and shallow depression at the middle; umbonal and median region narrowly sulcate; sulcus widening abruptly at the middle and extending to the anterior margin where it occupies more than half the width; sulcus occupied by 2 strong costae separated by a narrow sulcus which corresponds to the median costa of the opposite valve. Flanks moderately convex and with steep posterolateral slopes.

Measurements in mm.—111392a, length 4.0, brachial length 3.7, midwidth 3.2, widest part 3.3, thickness 2.0.

Figured specimen.—111392a.

Horizon and locality.—Meadow marble in Tennessee: 2 miles southeast of Kiser, Meadow (T.V.A. 139-NW) Quadrangle.

Genus *HALLINA* Winchell and Schuchert, 1892

Hallina WINCHELL and SCHUCHERT, Amer. Geol., vol. 9, p. 291, 1892.

HALLINA GLOBULARIS Cooper, new species

Plate 143, K, figures 48-52

Shell large for the genus, subcircular in outline; valves subequal in depth; sides gently rounded; anterior margin broadly rounded; anterior commissure faintly sulcate. Surface paucicostellate; costae confined to the anterior half and numbering about 20.

Pedicle valve strongly convex in lateral profile and with the maximum convexity just posterior to the middle; anterior profile strongly convex, somewhat narrowed medially and with long, steep, flat, lateral slopes. Umbonal region narrowly swollen; median region strongly swollen; anteromedian third or half flattened where a broad fold is very indistinctly visible; flanks steep. Beak strongly incurved. Beak ridge short and sharp.

Brachial valve strongly convex in lateral profile and with maximum depth at about the middle; anterior profile not so strongly arched as that of the pedicle valve but strongly convex nevertheless; median and umbonal regions inflated. Anterior third at the middle slightly flattened and forming a barely perceptible sulcus. Flanks swollen, steep sided.

Measurements in mm.—

| | Length | Width | Thickness |
|----------------|--------|-------|-----------|
| Holotype | 4.3 | 4.0 | 2.8 |
| Paratype | 4.1 | 3.9 | 3.0 |

Types.—Holotype: 117257a; unfigured paratype: 117257b.

Horizon and locality.—Auburn chert in Missouri: ½ mile east of Auburn, Elsberry (15') Quadrangle.

Discussion.—This species is the largest member of the genus known and is characterized by its globular form, rounded outline, and strongly swollen valves.

HALLINA LIRATA Cooper, new species

Plate 143, C, figure 12

Shell small, elongate oval in outline; valves subequally convex; sides and anterior margins rounded; anterior commissure rectimarginate. Surface marked by about 26 direct, rounded costellae.

Pedicle valve moderately convex in lateral profile and with the maximum convexity at the middle; anterior somewhat flattened; anterior profile broadly and moderately convex with long, moderately steep slopes. Umbonal region moderately inflated; median region strongly swollen, the swelling extending nearly to the margins; lateral slopes moderately steep. Interior with short dental plates.

Brachial valve moderately convex in lateral profile with the maximum convexity at about the middle; anterior profile broadly convex, less convex than the pedicle valve. Umbo narrowed slightly at the beak, otherwise broadly swollen; median region and flanks swollen.

Measurements in mm.—

| | Length | Width | Thickness |
|-----------------------------------|--------|-------|-----------|
| Holotype | 4.5 | 3.8 | ? |
| Paratype (C.U. 26401(1056)a)..... | 3.1 | 2.8 | 1.7 |

Types.—Holotype: Columbia Univ. 26401(1056); unfigured paratype: Columbia Univ. 26401(1056)a; unfigured and unnumbered paratypes on slab with holotype.

Horizon and locality.—Benner-Stover formation in Pennsylvania: In a small quarry west of the road 1 mile south of Jacksonville, Centre Hall (15') Quadrangle.

Discussion.—This species is distinguished from *H. saffordi* and *H. globularis* by its very fine costellae as compared to those of the other two.

HALLINA SAFFORDI Winchell and Schuchert

Plate 142, F, figures 26-28; plate 143, J, figure 47

Hallina saffordi WINCHELL and SCHUCHERT, Amer. Geol., vol. 9, p. 292, 1892; Geol. Minnesota, vol. 3, p. 473, pl. 34, figs. 55-58, 1895.—HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 151, figs. 139, 141, 1894.

Zygospira saffordi (Winchell and Schuchert) BEECHER and SCHUCHERT, Proc. Biol. Soc. Washington, vol. 8, p. 71, pl. 10, fig. 22; pl. 11, figs. 13, 13a, 1893.

Types.—Hypotypes: 123356a; 117258a.

Horizon and locality.—About the middle of the Lebanon formation in Tennessee: At Lebanon and on the west side of U. S. Highway 41, 9½ miles southeast of Murfreesboro, Rutherford County; Columbia, Maury County; and 2½ miles east of Priest, Franklin (15') Quadrangle.

Subfamily GLASSIINAE Schuchert, 1929

Small, smooth brachiopods with spirals compressed and directed toward the median part of the brachial valve and with the jugum continuous.

IDIOSPIRA Cooper, new genus

(Greek *idio*, own; *spira*, spire)

Shells generally small, approaching or slightly exceeding 15 mm. in length; subcircular to subelliptical in outline; valves subequal in depth; anterior commissure uniplicate; surface smooth, except for obscure short marginal costae at the anterior margins generally confined to the fold and sulcus.

Pedicle valve with small incurved beak, elongate, like that of *Protozyga*, open foramen, and small teeth. Dental plates strongly developed. Brachial interior with divided hinge plate; sockets deep and long; outer socket ridge well developed; hinge plates small, triangular, concave. Median ridge indistinct. Spire

similar to that of *Glassia* but with cones directed medially and toward the brachial valve.

Genotype.—*Camerella panderi* Billings, Canadian Nat. Geol., vol. 4, p. 302, 1859.

Discussion.—This genus has a very obvious camerelloid exterior appearance but it differs from the members of the subfamily in being much more rotund and in not having an erect beak. *Idiospira* differs from *Glassia* which it resembles in the form of the spire, in exterior and interior details. *Idiospira* has a strongly uniplicate anterior commissure although the fold of the brachial valve is seldom very prominent. The folding usually takes the form of an abrupt wave of the commissure and the development of a fairly strong tongue on the pedicle valve. *Idiospira* also has, in some species, more or less well developed costae along the margins.

Internally *Idiospira* differs from *Glassia* in possessing strong dental plates, a subdued median ridge, and a wide foramen. The spire is different in having the loose coils of the cone directed obliquely inward and toward the brachial valve rather than inward as illustrated for *Glassia*.

IDIOSPIRA ? INORNATA (Weller)

Camerella inornata WELLER, Geol. Surv. New Jersey, Rep. on Paleont., vol. 3, p. 157, pl. 10, figs. 8-10, 1903.

Although the interior characters of this species were not determined by Weller and the types have not been reexamined in this study, the description and figures make it clear that this species is not a *Camerella*. The tendency toward emargination of the anterior margin, the wave of the anterior commissure toward the brachial valve, the subequal depth of the valves, and the closely appressed beak of the pedicle valve are suggestive of assignment to *Idiospira*.

Horizon and locality.—Jacksonburg formation in New Jersey: On the hill just east of the station, near Hainesburg, Delaware Water Gap (15') Quadrangle.

IDIOSPIRA PANDERI (Billings)

Plate 108, F, figures 26-32; plate 195, F, figures 33-37; plate 195, H, figures 42-46

Camerella panderi BILLINGS, Canadian Nat. Geol., vol. 4, p. 302, 1859.—LOGAN, Geol. Canada, p. 143, fig. 78, 1863.—HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 220, pl. 62, figs. 19-23, 1893.—? RAYMOND, Ann. Carnegie Mus., vol. 7, p. 250, pl. 36, figs. 31, 32, 1911.—WILSON, Geol. Surv. Canada, Bull. 8, p. 118, pl. 11, fig. 2, 1946.

Two specimens of this species in the National Collection were prepared to show the spire. These revealed a fairly tightly coiled spire with the apices directed medially and obliquely toward the brachial valve. The details of the cardinalia furnished in the generic description were also taken from specimens of this species. *Idiospira panderi* has been widely identified in Trenton rocks of this country and Canada, but a revision of these is in order. The number of specimens of this genus in the National Collection is small, but a number of new species are here separated.

Idiospira panderi Billings is a globular species generally slightly longer than wide with a strongly uniplicate anterior commissure and a fairly well-marked fold on the brachial valve. The pedicle tongue is usually marked by a costa, and the fold has a short depression to accommodate it, thus giving the fold an anterior bicostate form.

Types.—Syntypes: G.S.C. 1148,a,b; figured hypotypes: 85329a, 85330a, 92374a,c, 117251a.

Horizon and locality.—Rockland formation in Quebec: On Allumette Island; same formation in Ontario: At Paquette Rapids; Stewarts Quarry, $2\frac{1}{2}$ miles south of Rockland.

Lower Trenton formation in New York: North of Amsterdam.

Tyrone formation in Kentucky: 2 miles south of High Bridge; Curdsville, Mercer County.

Auburn chert in Missouri: $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle.

Decorah formation (Guttenburg member) in Iowa: On M.St.P. and P. RR., 1 mile north of Eagle Point Bridge, Dubuque.

Hull formation in Ontario, Canada: At Kirkfield.

IDIOSPIRA ? WARTHINI Cooper, new species

Plate 140, K, figures 63-72; plate 195, G, figures 38-41

Shell large for the genus, length and width about equal in the adult; outline oval; apical angle about 100° ; sides rounded; greatest width located just anterior to the middle. Anterior commissure moderately strongly uniplicate; surface smooth except for 1 or 2 costae at the anterior margin.

Pedicle valve moderately convex in lateral profile and with the maximum convexity slightly posterior to the middle; anterior profile stronger than the lateral one and with short, moderately steep lateral slopes. Beak moderately long. Umbo and postmedian region swollen; sulcus originating at about midvalve, wide and shallow, forming a short, wide tongue. Tongue marked by 2 costae that extend almost to the middle of the valve. Sulcus bounded by 2 short, narrow costae. Flanks swollen and with steep sides.

Brachial valve moderately convex in lateral profile and with the maximum depth at the middle; anterior profile broadly domed. Umbonal and median regions swollen; fold inconspicuous, broad and low, confined to the anterior third to fifth; fold marked by 3 narrowly rounded costae. Flanks swollen, slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-----------------------------|--------|-----------------|-------|-----------|
| Holotype (C.U. 25919b)..... | 10.9 | 9.7 | 9.2 | 6.9 |
| Paratype (C.U. 25919a)..... | 12.2 | 10.9 | 12.0 | 7.2 |
| “ (U.S.N.M. 117252a)..... | 9.6 | 8.9 | 8.9 | 4.9 |

Types.—Holotype: Columbia Univ. 25919b; figured paratypes: Columbia Univ. 25919a; U.S.N.M. 117252a.

Horizon and locality.—Wappinger formation in New York: In the railroad

cut at Pleasant Valley, 6 miles northeast of Poughkeepsie, Poughkeepsie (15') Quadrangle.

Discussion.—This species is unlike any other described American form. It is larger and less globular in form than *I. panderi* and has more costae in the fold and sulcus. It is most like *Camarella thomsoni* (Davidson) from the Stinchar formation at Craighead, Girvan, Scotland. It differs from the Scottish species in its larger size, less convex brachial valve and less costate anterior margin. The Scottish species has 4 costae on the fold and a costa on each flank.

Superfamily SPIRIFERACEA Waagen, 1883

Family CYCLOSPIRIDAE Schuchert, 1913

Spiriferacea with the crura continuous with the bases of the close-set, nearly parallel primary lamellae; spiralia slightly introverted and with few volutions. No jugum.

Genus CYCLOSPIRA Hall and Clarke, 1893

Cyclospira HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 146, 1893.

CYCLOSPIRA BISULCATA (Emmons)

Plate 142, L, figures 54-59

Figures of this species, which is the type of the genus and a large form, are introduced for comparison with species assigned to *Cyclospira* from the Appalachian Valley and elsewhere.

Figured specimen.—88272a.

Horizon and locality.—Coburg formation (upper), in New York: In the quarry east of Black River below Copenhagen, Carthage (15') Quadrangle.

CYCLOSPIRA ? LONGA Cooper, new species

Plate 142, I, figures 39-43

Shell small, pentagonal in outline, longer than wide with the greatest width at about the middle. Beak acute; shell posterior to middle narrowing rapidly to the beak; sides somewhat narrowly rounded; anterior margin narrow and gently rounded. Anterior part of anterolateral extremities marked by 2 costae; surface without other ornament than the costae and folds.

Pedicle valve about twice as deep as the brachial valve, moderately convex and with the greatest convexity slightly posterior to the middle. Beak moderately incurved. Umbo narrowly swollen. Fold low, extending to a point slightly anterior to the middle where it passes into 2 narrowly rounded costae bounding a narrow sulcus. Flanks gently concave and with steep slopes to the margins.

Brachial valve evenly and gently convex in lateral profile, with greatest convexity at about the middle. Posterior half slightly swollen and marked by a shallow and narrow depression that marks the position of the median septum. Sulcus originating slightly anterior to the middle, widening rapidly to the margin where it occupies about half the valve width. Sulcus for its entire length occu-

pied by a narrowly rounded fold bearing a slight median longitudinal groove. Furrows defining median fold deep; folds bounding sulcus low but narrowly rounded. Median septum extending to point of origin of median fold.

Measurements in mm.—Holotype, length 4.0, width 3.6, thickness 2.3.

Type.—Holotype: III390.

Horizon and locality.—Rysedorf conglomerate, near Albany, N. Y.

Discussion.—This species is close in form and outline to *C. sulcata*, but unlike that species it is costate on the flanks, a feature uncommon in later species of *Cyclospira* as far as known. The Rysedorf species differs from the Tennessee one in having an elongated and narrow beak and a strong, narrow median fold in the sulcus of the brachial valve. This species is placed in *Cyclospira* because of the long, prominent, and thick median septum. The exterior resemblance to *Protozyga* is striking, but the median septum is stronger than usual in that genus.

CYCLOSPIRA PARVA Cooper, new species

Plate 142, K, figures 49-53

Shell small for the genus, subpentagonal in outline, with the greatest width located at about the middle; lateral margins rounded; front margin narrowly rounded; surface smooth.

Pedicle valve with strongly incurved beak; umbo and beak in profile forming an acute angle. Umbo swollen and somewhat carinated, extended forward to the front margin as a narrowly rounded fold. Fold flattened in the anterior third; flanks in anterior profile forming an angle of about 90°, flattened to slightly concave and with steep slopes to the margins.

Brachial valve about a third as deep as the pedicle valve, gently convex in lateral profile; umbonal region slightly inflated; sulcus originating just anterior to the umbo and extending to the front margin, widening and deepening anteriorly. Flanks bounding sulcus well rounded and with moderately steep lateral slopes.

Interior: Median septum extending about half the length of the valve; spire extending well beyond the middle.

Measurements in mm.—Holotype, length 4.1, width 3.6, thickness 2.3.

Types.—Holotype: III391a; unfigured paratypes: III391b-d.

Horizon and locality.—Bromide formation (Pooleville member—*Oxoplectra gouldi* zone) in Oklahoma: Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

Discussion.—This species is smaller than *C. sulcata*, which it resembles, and has a shorter sulcus. *C. sulcata* gives a more square-shouldered appearance than the Oklahoma species.

CYCLOSPIRA PRECIOSA Cooper, new species

Plate 141, E, figures 25-32

Shell moderately large for the genus, length and width of a large adult about equal; pentagonal in outline; sides rounded and with the maximum width at or

near the middle; anterior narrowed and truncated; strongly sulcate; surface smooth.

Pedicle valve strongly convex in lateral profile, with the maximum convexity anterior to the umbo; anterior profile narrowly convex and with steep, flattened lateral slopes. Beak narrow and strongly incurved; umbo narrowly rounded; median region narrowly rounded; anterior region with low, narrow fold, flattened or depressed longitudinally by a more or less shallow depression extending from the anterior margin to the middle. Flanks flat or gently concave and steep.

Brachial valve moderately convex in lateral profile, the posterior half fairly strongly convex but the anterior half bent strongly toward the pedicle valve. Anterior profile broadly sulcate. Umbonal region marked by a shallow, narrow sulcus which widens rapidly and deepens anteriorly. Flanks swollen and narrowly convex. Sulcus without inner fold except near anterior margin where it is more or less distinct.

Measurements in mm.—

| | Length | Brachial length | Width | Thickness |
|-------------------------|--------|-----------------|-------|-----------|
| Holotype | 6.5 | 5.7 | 5.9 | 3.9 |
| Paratype (117253a)..... | 6.6 | 5.5 | 5.8 | 4.0 |
| " (117253c)..... | 6.9 | 6.1 | 6.5 | 4.2 |

Types.—Holotype: 117253b; figured paratypes: 117253a,c.

Horizon and locality.—Edinburg formation (Lantz Mills facies) in Virginia: 90 feet above the *Dinorthis transversa* zone and 90 feet below the *Oligorhynchia* zone, 0.6 mile northwest of the junction of Virginia County Highways 616 and 621, Richpatch, Eagle Rock (15') Quadrangle.

Discussion.—This species resembles *C. bisulcata* but does not attain the large size of the later Trenton species. *Cyclospira bisulcata* is a much more robust form and has a more prominent fold in the sulcus of the brachial valve.

CYCLOSPIRA QUADRATA Cooper, new species

Plate 141, A, figures 1-12; plate 143, B, figures 7-11

Shell small for the genus, length and width about equal; pentagonal in outline; sides rounded; greatest width at about the middle; shoulders prominent. Surface smooth.

Pedicle valve fairly strongly convex in lateral profile; narrowly humped in anterior profile. Beak long, incurved; umbo somewhat inflated; median region narrowly convex; front with a poorly defined fold flattened on its surface. Flanks flat but sloping steeply to the margins.

Brachial valve unevenly convex, the posterior half somewhat inflated but the anterior half extending toward the pedicle valve; anterior profile broadly and gently convex. Umbo and median region inflated; sulcus narrow and shallow at the posterior but broad and fairly deep anteriorly. Flanks moderately inflated.

Measurements in mm.—

| | Length | Width | Thickness |
|--------------------------|--------|-------|-----------|
| Holotype | 4.4 | 4.3 | 2.2 |
| Paratype (117256b) | 4.2 | 4.1 | 2.4 |

Types.—Holotype: 117256a; figured paratypes: 117254, 117255a, 117256b.

Horizon and locality.—Edinburg formation (top of the Liberty Hall facies) in Virginia: $\frac{1}{2}$ mile south of Dunkard Church, 6.9 miles S. 80° W. of Natural Bridge, Natural Bridge (15') Quadrangle.

Edinburg formation (lower *Nidulites* zone) in Virginia: From a cut on U. S. Highway 11, Hupp Hill, 1 mile north of Strasburg, Strasburg (15') Quadrangle.

Martinsburg formation (= Salona) in Virginia: On Virginia Highway 617 = 910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is characterized by small size, and quadrate form. It is suggestive of *C. sulcata* but is less elongate and has a shorter and wider sulcus. The same features will distinguish it from *C. parva*.

CYCLOSPIRA SULCATA Cooper, new species

Plate 142, M, figures 60-69

Shell small, pentagonal in outline, inequivalved; lateral margins gently rounded but with distinct shoulders located slightly posterior to the middle; greatest width at or slightly anterior to the shoulders. Front margin truncated. Surface smooth.

Pedicle valve deep, evenly and moderately convex in lateral profile, strongly convex in adult forms with the greatest convexity shifted to the umbonal region. Median region strongly elevated and narrowly rounded to form a low fold; sides gently concave and diverging steeply to the margins. Anterior slope steep.

Brachial valve shallow, moderately convex in lateral profile and with the maximum curvature located at the front of the adult where the valve is geniculated to form a tongue which fits into the anterior folded part of the pedicle valve. Umbonal region slightly swollen; sulcus originating somewhat less than a third the length from the beak, broad, deepening anteriorly, and with rounded section. Flanks gently convex, narrow.

Interior: Median septum of the brachial valve extending almost to the middle; descending processes of spire reaching nearly to front margin.

Measurements in mm.—

| | Length | Width | Thickness |
|----------------|--------|-------|-----------|
| Holotype | 4.8 | 4.3 | 2.7 |
| Paratype | 4.6 | 3.7 | 2.0 |

Types.—Holotype: 111395b; figured paratype: 111395a.

Horizon and locality.—Sevier formation in Tennessee: 1 mile southeast of Whitehorn, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Chatham Hill formation in Virginia: Grayson Farm, 4 miles southwest of Bland, Bland County.

Discussion.—This species can be recognized by its broad and rounded sulcus in the brachial valve and the typically shouldered appearance of the pedicle valve. It is different from *C. longa* in lacking a strong fold in the sulcus and obscure costae on the flanks. Its differences from *C. quadrata* and *C. parva* are stated under the discussion of those species.

Genus **TRIPLECELLA** Wilson, 1932

Triplecella WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 26, sec. 4, p. 399, 1932.

Examination of the type specimen of this genus indicates that it belongs to *Cyclospira* and is not a new genus at all. The type specimen is a single valve marked medially by a moderately wide sulcus. At about the middle of the valve a fold appears in the sulcus and widens anteriorly to occupy nearly all of the sulcus at the front margin. In anterior profile the flanks bounding the sulcus are narrowly convex and elevated slightly above the fold in the sulcus. Although the original description states that "only one valve is known which appears to be the pedicle valve," comparison with the brachial valve of *Cyclospira* indicates that the sulcation and development of a fold within the sulcus so characteristic of *Triplecella* is identical to the folding in the brachial valve of *Cyclospira*. *Cyclospira bisulcata* occurs in the Coburg formation which is the horizon of *Triplecella*. It seems evident, therefore, from exterior details, that *Triplecella duplicata* is actually a brachial valve of *C. bisulcata*.

Suborder STROPHOMENOIDEA Maillieux, 1932

Superfamily PLECTAMBONITACEA Cooper and Williams, 1952

Family TAFFIIDAE Ulrich and Cooper, 1936

Shallow concavo-convex Strophomenoidea having a pseudodeltidium and chidium; brachial valve with cardinalia like those of the Orthidae, with or without a cardinal process.

Genus **TAFFIA** Ulrich, 1926

Taffia Ulrich in BUTTS, Alabama Geol. Surv. Special Rep. 14, p. 99, pl. 18, figs. 13-17 (no description), 1926.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 180, 1938.

TAFFIA PLANOCONVEXA Butts

Plate 172, E, figures 21-29

Taffia planoconvexa Butts, ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 181, pl. 37C, figs. 12-18, 1938.

Figures of this genus are introduced for comparison with *Aporthophyla*, *Toquimia* and members of the Plectambonitacea. *Taffia* is at present the earliest known strophomenoid brachiopod and is the possible progenitor of some of the higher stocks. Its affinities to members of the Orthidae are obvious when the figures of *Taffia* are studied.

Types.—Lectotype: 71461b; figured paratype: 71461a; figured hypotypes: 91586, 91588a, 91590a,b.

Horizon and locality.—Odenville formation in Alabama: In the vicinity of Odenville, St. Clair County.

Genus APORTHOPHYLA Ulrich and Cooper, 1936

Plate 163, C, figures 21-24; plate 164, A, figures 1-3

Aporthophyla ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 625, 1936; Geol. Soc. Amer. Special Pap. 13, p. 182, 1938.

This is another genus having rafinesquinoid appearance but with orthoid cardinalia, strong dental plates, and orthoid muscle scar in the pedicle valve. Illustrations of two species are introduced for comparison with *Toquimia*, *Palaeostrophomena*, and other Plectambonitacea.

Genus TOQUIMIA Ulrich and Cooper, 1936

Plate 164, B, figures 4-14; plate 195, E, figure 32

Toquimia ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 626, 1936; Geol. Soc. Amer. Special Pap. 13, pp. 183-184, 1938.

In the summer of 1946 Cooper visited the type locality of *Toquimia kirki* Ulrich and Cooper in Ikes Canyon, Toquima Range, Nev., and collected specimens which add information to our knowledge of the genus and which help to correct previous errors.

The exterior of the shell is definitely rafinesquinoid, but the brachial valve becomes flat or gently convex in the anterior half. Inside the pedicle valve the muscle field is large and has subflabellate diductor-adjustor impressions. Anterior to the adductor scars and enclosed by the diductors is an oval pit. Anterior to the diductors is a large callosity suggestive of the one seen in *Titanambonites* or *Sowerbyites*. The visceral region is defined by an elevated ridge a few millimeters inside the anterior margin. Over this ridge and on the flat area anterior to it are located the main distributaries of the pallial trunks.

An error mentioned in connection with the pedicle valve in the original description is the statement that a minute foramen is present. The new material includes specimens showing the interareas and beaks to perfection (117567h), but presence of a foramen was unconfirmed.

An excellent brachial interior was obtained by dissolving the shell from a piece of sandy matrix. This specimen reveals a thin median septum rising to a low crest just anterior to the middle. The cardinal process is short-shafted but with a bulbous myophore which bears a strong median ridge and a weaker one on each side. The brachial processes are short, flat blades. Like the pedicle valve, the brachial valve has a thickened area about 5 mm. posterior to the anterior margin. The thickening is strongest where the median septum terminates. The pallial distributaries form channels in the thickening and extend across the low marginal area to the anterior margin. The thickened area of the pedicle valve lies somewhat anterior to that of the brachial valve and the two serve as a straining device when the valves are in contact.

Toquimia is suggestive of *Palaeostrophomena* and is undoubtedly related to that genus. *Toquimia* has, however, a different lateral profile, rafinesquinoid ornamentation, lesser development of the median ridge, more flabellate muscle scars, and greater development of subperipheral thickenings. The differences be-

tween *Toquimia* and *Aporthophyla* have been stated by Ulrich and Cooper (1938, p. 182).

Types.—Lectotype: 91595a; paratypes: 91595b-f; figured hypotypes: 117567a, d, e, f, h, j; unfigured hypotypes: 117567b, c, g, i.

PELONOMIA Cooper, new genus

(Greek *pelos*, mud; *nomos*, abode)

Shell small, subrectangular in outline with the hinge as wide or wider than the midwidth; planoconvex in profile; pedicle valve with median fold and brachial valve with median sulcus. Surface finely multicostellate. Shell substance coarsely pseudopunctate.

Pedicle valve with short interarea and rudimentary pseudodeltidium. Muscle area small, wider than long, bounded by short, thick dental plates and an anterior rim.

Brachial valve with generalized interior consisting of a small, thickened but simple cardinal process and rounded chilidium. Notothyrial cavity shallow, bounded by short, delicate, primitive, rodlike brachiophores. Median ridge absent but its place marked by two rows of strong but distant nodes. Rest of surface coarsely but distantly granulose.

Genotype.—*Orthis delicatula* Billings, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 217, 1865.

Discussion.—This little genus is particularly characterized by its planoconvex form, coarse pseudopunctae, and the generalized character of the brachial interior. It is unique among these early brachiopods in lacking a median ridge or median septum. The exterior is plectambonitid, but the plectambonitid brachiopods are generally characterized by one or more septa. *Pelonomia* suggests *Eostrophomena* Walcott in its shape and size, but that genus has a different cardinal process and possesses a median ridge.

PELONOMIA DELICATULA (Billings)

Plate 223, E, figures 8-10

Orthis delicatula BILLINGS, Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 217, 1865.

Figured hypotypes.—117557, 117558.

Horizon and locality.—Table Head series in Newfoundland: At Table Head; 4 miles northeast of Portland Creek; 1 mile west of Aguathuna, Port-au-Port.

Family PLECTAMBONITIDAE Kozłowski, 1929

Strophomenoidea with normal or reversed convexity, usually finely costellate. Cardinal process simple. Brachial processes short and slender. Pseudodeltidium and chilidium present.

Subfamily PLECTELLINAE Öpik, 1930

Finely costellate, with simple orthoid cardinal process, imperforate pseudodeltidium.

Genus **INGRIA** Öpik, 1930

Plate 163, B, figures 7-20

Ingria ÖPIK, Brachiopoda Protremata der estländischen Ordovizischen Kukruse-Stufe, Acta et Comment. Univ. Tartu, ser. A, vol. 17, No. 1, p. 57, 1930; idem, ser. A, vol. 23, No. 3, pp. 13-17, 1932.—ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 185, 1938.

Palinorthis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 625, 1936.

In 1936 Ulrich and Cooper proposed the genus *Palinorthis* for an unusual species from the Ordovician east of Frenchman Flat, Las Vegas (1°) Quadrangle, in southern Nevada, with genotype *P. cloudi*. This genus later proved to be a synonym of Öpik's genus *Ingria*. In 1939 Bridge and Cooper collected additional material of *Ingria cloudi*. After being etched from the limestone the specimens constitute an excellent series. The species proves to be a variable one, but the variations include even minor details shown by Öpik's specimens from Rogö Island.

As revealed by the Nevada examples *Ingria* possesses the peculiar double tooth so prominent in *Palaeostrophomena*. It also has a few accessory denticles on the hinge margin on each side of the tooth. Some specimens show an unusually large development of the adustor scars. Most of the specimens have the beak filled with adventitious shell deposited under the pseudodeltidium and welding that structure to the apex. Considerable variation occurs in the cardinal process; it varies from slender to moderately thick but retains its septumlike character in all the specimens. In the pedicle valve the thickening anterior to the adductor scars varies from a slender ridge to a wide triangular or somewhat rhomboidal patch.

This genus so far has been found in the United States only at the Frenchman Flat locality.

Types.—Figured hypotypes: 117559b-g,j; unfigured hypotypes: 117559a,h,i.

Family LEPTESTIIDAE Öpik, 1933

Plectambonitidae with shells of normal and reversed convexity, having a prominent median ridge or septum. Cardinal process trilobed and chilidium narrowly elevated.

Subfamily LEPTESTIINAE Öpik, 1933

Leptestiidae with prominent median septum.

Genus **PALAEOSTROPHOMENA** Holtedahl, 1916 (emend. Öpik, 1933)

Palaeostrophomena HOLTEDAHL, Vidensk. Skrift., I, Mat.-Nat. 1915, No. 12, p. 43, 1916; emended, Öpik, Acta et Comment. Univ. Tartu, ser. A, vol. 24, p. 24, 1933.

Holtedahl named *Strophomena concava* F. Schmidt as type of his new genus. Later work by Öpik, however, showed that the named type and the Norwegian specimens figured by Holtedahl are not congeneric. Öpik therefore proposed the genus *Inversella* for the *S. concava* of Holtedahl (not Schmidt) and emended *Palaeostrophomena* on the basis of a study of Schmidt's type specimens of *S. concava*.

Several species of Appalachian brachiopods appear to conform to the details of the emended *Palaeostrophomena* as described and illustrated by Öpik. The Esthonian shells, however, differ from the American ones in size, thickness of shell, and ornamentation. The Esthonian specimens are more wrinkled and are larger than any of the American species. The interior details of the American species conform to those of *Palaeostrophomena* described and illustrated by Öpik. Details of the interior of the pedicle valve of the Esthonian form, however, are not known, and this gap in knowledge leads to some doubt as to precise generic assignment. In spite of this gap in our knowledge the American shells are assigned to the emended *Palaeostrophomena*. The following remarks on generic characters are based on the five known American species.

The lateral profile is resupinate, i. e., the young shell is generally concavo-convex but in the adult the convexity is reversed. Thus the young stages of *Palaeostrophomena* have normal convexity, but the anterior of the pedicle valve is more or less deeply concave and that of the brachial valve is more or less strongly convex. The ornamentation consists of costellae of unequal size, the stronger ones separating groups of finer ones. Strong concentric wrinkles are a common feature of the Esthonian shells, but in the American species these are generally confined to the posterior margins. Both interareas are moderately long; the notothyrium and delthyrium are both narrow and are covered by strongly elevated and narrowly convex chilidium and pseudodeltidium.

Inside the pedicle valve the teeth form one of the most prominent features because they are double, consisting of the tooth and an accessory dental process. The tooth consists of a flat blade that grows obliquely forward from the apex. Normally the inner edge of the tooth track forms the margin of the delthyrium, but in *Palaeostrophomena* a deposit of shell substance is laid on the inner side of the tooth to protrude at its anterior end. In articulation the tooth rests on the outer or socket surface of the brachiophore and the accessory tooth rests on the inner surface of the brachiophore. The narrow space between the tooth and the accessory tooth receives the carinate edge of the brachiophore. The accessory tooth seems to be formed of adventitious deposit.

Dental plates are lacking in the adult forms of the American shells and seem also to be lacking from the specimens figured by Öpik. False dental plates, however, composed of adventitious shell extend from the teeth for a short distance on each side of the muscle field forming a fairly high ridge in some instances.

The muscle field of the pedicle valve of all the known species is large and occupies a generous portion of the interior. The field is generally pentagonal in outline with the muscle scars converging to the apex and subparallel on the sides. The anterior is deeply emarginate. Adjustor scars are visible at the base of the accessory teeth or their extensions, the false dental plates. The diductor scars are elongate, narrow, and usually extend to the valve middle or anterior to it. In some specimens low callosities appear at the anterior ends of the diductor scars. The adductor field forms a short, flattish, somewhat rectangular scar, often with longitudinal striation at the apex. Its anterior end never reaches the anterior

ends of the diductors. Actually the diductor scars are often separated by a callosity or elevation at the anterior end of the adductor field.

The pallial marks of the pedicle valve are deeply impressed in all species of the genus. A prominent trunk is given off at the anterior end of each of the diductors, one branch of which turns toward the middle and then turns again to extend to the front margin. Another branch extends almost directly toward the front margin while the third branch turns posterolaterally. All these branches send off numerous subsidiary channels. The pallial marks themselves consist of narrow channels separated by low ridges so that each main pallial trunk in reality consists of two narrow parallel channels.

The ovarian impressions are usually large and well developed.

The pseudodeltidium is a narrow arch with its side laid against the deposit forming the accessory tooth. The plate is further cemented by adventitious shell laid on the sides of the delthyrial cavity and the inner surface of the pseudodeltidium.

The brachial interior of American *Palaeostrophomena* is known well in three species. These have deep sockets and flat-bladed, rather delicate brachiophores. These are distinctly orthoid in structure. The notothyrial platform is moderately thickened and is the seat of attachment of a prominent cardinal process. The shaft of this structure is short and stout; the myophore is characterized by a strong and elevated median ridge which stands between two lower ridges. The three ridges are subparallel and separated by deep but narrow grooves. The chilidium arches over the myophore and nearly covers it. The brachiophores and cardinal process are completely independent. The median ridge is narrow and strongly elevated, rising to a point anteriorly and sharply cut off at the front. The adductor field is moderately wide at the posterior and tapers to a point anteriorly. The posterior scars are the larger, and both scars may be striated and elevated on the margins.

Pallial marks are prominent in the brachial valve as well as in the pedicle valve. As in the other valve the pallial trunks consist of parallel narrow grooves separated by low ridges. A major trunk extends anteriorly on each side of the median ridge. Another trunk extends more or less obliquely from the point of separation of the anterior and posterior adductor pairs. Ovarian impressions are strongly developed as in the opposite valve.

PALAEOSTROPHOMENA ANGULATA Cooper, new species

Plate 168, B, figures 3-10; plate 194, C, figures 19-22

Shell small for the genus, wider than long with the width at the hinge varying from about $1\frac{1}{2}$ to 2 times the length. Cardinal extremities acutely angular, auriculate to submucronate. Lateral margins sloping inward; anterior margin broadly to narrowly rounded. Surface beautifully ornamented by costellae of different sizes and fine concentric fila. Costellae of three sizes, the larger ones appearing in three generations, a median costella stronger and wider than the rest usually marks the center of the pedicle valve. Umbonal region usually marked by 3

primary costellae on each side of the median one. Costellae of intermediate size intercalated in 2 generations as the shell grows so that an adult has about 8 of the primary and intermediate costellae in a space of 5 mm. at the front margin. Spaces between larger costellae occupied by about 4 very fine costellae that are cancellated by crowded concentric fila. Oblique wrinkles, often of considerable length, mark the shell just anterior to the posterior margin.

Pedicle valve nearly flat in lateral profile; very slightly convex in the posterior half but flattened in the anterior portion. Umbo narrow, slightly swollen; beak small and protruding slightly posterior to the posterior margin. Anterolateral region flanking depressed anterior part thrown into a slight broad fold. Cardinal extremities somewhat flattened. Interarea short and flat; apsacline to nearly procline; pseudodeltidium narrow and strongly convex.

Brachial valve only partially known from the exterior. Umbonal region concave. In order to fit the interior of the pedicle valve the brachial valve must be slightly convex in the anterior region.

Interior of pedicle valve with a moderately deep delthyrial cavity well filled at the posterior by callus. Valve well thickened just inside the periphery, this thickened portion of the interior giving the resupinate profile to the species. Muscle field large, occupying most of the visceral region. Adjustors located at the base of the dental plates as usual; diductor scars long and slender, generally with a low ridge running the length of the middle of the scar. Adductor impressions large. Pallial sinuses deeply impressed. Teeth double; dental plates stout, giving off ridges that bound the exterior of the muscle field.

Brachial valve with cardinal process typical of the genus.

Measurements in mm.—

| | Length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|----------|-------------|-----------|
| Holotype | 8.1 | 11.0 | 15.4 | ? |
| Paratype (111080b) | 8.5 | 12.8 | 15.8 | ? |
| “ (111080c) | 8.0 | 11.6 | 13.9 | ? |
| “ (111084) | 7.9 | 10.8 | 12.1 | ? |

Types.—Holotype: 111080a; figured paratypes: 111080b-f, 111084, 111085a,b; unfigured paratype: 111080g.

Horizon and locality.—Botetourt formation in Virginia: $\frac{1}{2}$ mile southwest of Catawba at the junction of Virginia Highways 311 and 114, Salem (15') Quadrangle.

Discussion.—This species may be recognized by its great width, well-developed cardinal angles, beautiful surface ornamentation, and short interarea on the pedicle valve. The species can be distinguished from *P. subtransversa* which it most nearly resembles by its smaller size, less numerous large costellae, and nearly flat pedicle valve. The greater proportional length of *P. superba* will distinguish that species.

Palaeostrophomena angulata occurs in countless numbers at its type locality, yet not a single good brachial valve was obtained. By far the majority of specimens are isolated pedicle valves, but specimens with both valves in contact do

occur. Strangely, these specimens usually have the brachial valve crushed onto the inside of the pedicle valve so that the posterior part of the two valves is frozen together. The brachial valve must have been a more delicate shell than the pedicle one.

PALAEOSTROPHOMENA RESUPINATA Cooper, new species

Plate 167, A, figures 1-28

Shell large, semielliptical in outline, wider than long with the hinge forming the greatest width. Lateral margins gently convex; anterior margin fairly strongly convex. Surface multicostellate, costellae of varying sizes, 11 of the larger ones occupying a space of 5 mm. at the front margin.

Pedicle valve convex in the front half in lateral profile but concave in the anterior half. Beak broadly obtuse, scarcely protruding posterior to the posterior margin. Umbonal and posteromedian region swollen. Valve geniculated gently in the direction of the pedicle valve about 7 mm. anterior to the beak. Geniculated half gently concave, the maximum concavity extending around the swollen portion from the middle of the valve to the posterior margin. Cardinal extremities flattened slightly, interarea long, strongly apsacline. Delthyrium covered by a narrow, convex pseudodeltidium.

Brachial valve gently concave in the umbonal region and for a radius of about 6 to 7 mm. anterior to it. Anterior portion of the valve moderately convex except in the posterolateral areas where it is slightly concave just anterior to the cardinal extremities. The interarea short, flat, hypercline.

Interior of pedicle valve with most of interior occupied by a large and deeply impressed muscle field. Adjustor scars long and slender; diductor impressions reaching anterior to the middle; posterolateral margin of muscle field with more or less well developed marginal ridge; vascula media located at anterior end of diductor scars; secondary trunks deeply impressed; adductor track elevated and thickened.

Brachial interior with short brachiophores supported by a lateral thickening of the notothyrial platform; median ridge narrow, moderately elevated and extending anterior to the middle; cardinal process with thick shaft; myophore with elevated median crest. Pallial and ovarian impressions strongly marked.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 17.6 | 17.3 | 20.5 | 20.7 | 5.0 |
| Paratype (111069a) | 16.7 | 16.1 | 20.7 | 23.4 | 3.6 |
| " (117377d) | 11.2 | 10.5 | 14.3 | 15.8 | 2.7 |
| " (123249a) | 14.7 | 13.7 | 18.2 | 17.2 | 2.8 |
| " (123249b) | 13.0 | 12.6 | 16.7 | 17.9 | 2.9 |

Types.—Holotype: 117377h; figured paratypes: 111069a, 111078c,d, 117377a, c-g; unfigured paratypes: 111069b, 111078a,b,e, 117377b, 123249a-c.

Horizon and locality.—Benbolt formation (lower) in Virginia: Just east of meridian 17°30", east of Moccasin Creek, on north edge of Mendota (T.V.A.

197-NE) Quadrangle; on the west slope of the hill $\frac{1}{2}$ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle; south side Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; $\frac{1}{4}$ mile east of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

Same formation in Tennessee: On the north side of the road 1.1 miles north-east of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle.

Discussion.—This species most closely resembles *P. superba* of the species described in this monograph but differs in its larger size, thick valves, and more rounded front margin. The anterior margin of *P. superba* is narrowly rounded to subnasute with lateral margins sloping inward. *P. superba* is somewhat more concave in the geniculated region than *P. resupinata* but is much less convex on the brachial side.

PALAEOSTROPHOMENA ? RUGOSA Cooper, new species

Plate 176, B, figures 6-12

Shell large for the genus, wider than long, strongly resupinate; hinge forming the greatest width and with acute cardinal extremities. Sides nearly straight to oblique; anterior margin strongly rounded. Surface costellate, costellae in two sets, a larger group in a field of fine costellae; 6 or 7 of the larger costellae in 5 mm. at the front margin. Posterior margin marked by strong, oblique wrinkles; disk region of both valves marked by chevron-shaped wrinkles confined between 2 of the larger costellae.

Pedicle valve with posterior half convex in lateral profile but anterior half strongly concave; umbo and surrounding region moderately swollen; most deeply concave at about valve middle where shell geniculates in the direction of the pedicle valve; sides and anterior half bent strongly in the direction of the pedicle valve; interarea moderately long, apsacline. Interior with long, slightly divergent diductor scars.

Brachial valve fairly deeply concave in the umbonal and median regions to about the middle of the valve where it is bent strongly toward the pedicle valve. Angle of geniculation about 135° . Sides and anterior half gently convex in profile and forming steep lateral and anterior slopes. Interior with bulbous cardinal process, long and low median ridge most elevated at anterior end slightly anterior to the valve middle; brachioophores thin, small, orthoid. Myophore strongly trilobed. Pallial impressions forming deep and narrow channels.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 13.8 | 13.6 | 16.9 | 18.6 | 3.1 |
| Paratype (117378a) | 14.7 | ? | 19.4 ? | 22.3 | ? |

Types.—Holotype: 117379c; figured paratypes: 117379a,e,g; unfigured paratypes: 117378a-c, 117379b,d.

Horizon and locality.—Botetourt formation in Virginia: On the south side of U. S. Highway 60, about 1 mile northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species is characterized by its strongly resupinate profile and the presence of *Ptychoglyptus*-like wrinkles in the visceral region. It is thus unlike any other species of *Palaeostrophomena* described herein. This species may ultimately receive another generic designation, but it is not possible from the material at hand. The brachial interior with its fairly strong median ridge agrees with *Palaeostrophomena* although more material may prove this species to be a resupinate form of *Ptychoglyptus*.

PALAEOSTROPHOMENA SUPERBA Cooper, new species

Plate 169, C, figures 13-29; plate 184, E, figures 13-18

Shell small for the genus, strophomenoid in habit, subtrapezoidal to subtriangular in outline. Cardinal extremities acutely angular to auriculate. Lateral margins concave just anterior to the cardinal extremities, slightly rounded and oblique to the anterolateral region; front margin narrowly rounded. Anterior commissure broadly uniplicate. Surface marked by costellae of unequal size. Young shells and the posterior part of older ones marked by a few primary costellae, 4 or 5 on each side of a prominent median costella. Between the primary costellae 2 generations of intermediate size are intercalated, from 12 to 18 occupying a space of 5 mm. at the front margin. Space between intermediate and primary costellae covered by fine radial costellae. Posterior margin marked by oblique wrinkles.

Pedicle valve gently convex in the posterior region, becoming gradually concave at about two-thirds the length where the valve is gently geniculated in the direction of the pedicle valve. Umbonal region narrow and convex, extended forward as a low fold to about the middle. Anterior third gently concave with the concavity extending posterolaterally between the lateral margins and the folded median part of the valve. Beak forming a blunt point, extending slightly beyond the posterior margin. Interarea broad and flat, strongly apsacline. Delthyrium and pseudodeltidium narrow.

Brachial valve following the curvature of the pedicle with the posterior third gently concave and the anterior two-thirds flat to gently convex. Umbo and umbonal region moderately deeply concave and forming a sulcus corresponding to the fold on the pedicle valve in the posterior third to half. Sulcus lost where valve begins to flatten before geniculating. Region about cardinal extremities moderately to steeply sloping toward the margins. Lateral and anterior slopes moderately steep but the latter not as steep as the lateral slopes. Interarea shorter than that of the pedicle valve, flat to slightly convex, hypercline. Chilidium short, narrow, strongly arched.

Interior of pedicle valve with small teeth consisting of two articulating processes: the tooth proper and a process on the inside of the tooth formed by an extension of the sides of the deltidium. Delthyrial cavity moderately deep. Dental plates, if present, obscured by callus deposit. Cardinal margin greatly extended in an anterior direction by deposition of callus under the palintrope and flush with the cardinal edge. Low ridges surround posterior sides of the muscle

field. Adjustor scars long and slender, located on the outside margin of the muscle field just inside the lateral ridge. Diductor impressions long and slender extending for fully a third the length of the valve. Adductor impressions forming an oval field with the pointed end extending into the callus filling the posterior end of the delthyrial cavity. Pallial impressions deeply entrenched in the shell; the main vascula media extending from the anterior ends of the diductor scars for a short distance and then branching. Vascula media separated by a low, wide thickening of the shell. A second pallial trunk originates at about the anterior end of the adjustor scar. Ovarian impressions small.

Brachial interior with a stout median ridge extending to about the middle of the valve where its end is thickened and elevated. Brachial processes short and stubby (?); notothyrial cavity filled by callus and notothyrial platform occupied by a large cardinal process with bulbous shaft when viewed from the pedicle valve side. In posterior view the process is a thin, elevated median ridge intimately grown with the chilidium. Adductor impressions elongate, thickened at the front edge of the anterior scar which lies inside the posterior smaller scar. A pallial trunk extends anteriorly on each side of the median ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.5 | 9.0 | 11.6 | 13.6 | 1.5 |
| Paratype (111070f) | 9.1 | 8.3 | 12.3 | 14.8 | 1.8 |
| " (111070-1) | 12.3 | ? | 13.6 | 16.4 | ? |
| " (117381a) | 12.4 | 11.9 | 14.0 | 15.5 | 2.1 |

Types.—Holotype: 111070m; figured paratypes: 111070f-i,l,p, 117380, 117381a-c; unfigured paratypes: 111070a-e,j,k,n,o, 117381d-n.

Horizon and locality.—Arline formation on Concord (T.V.A. 138-SW) and Louisville (T.V.A. 138-SE) Quadrangles in Tennessee: $\frac{1}{4}$ mile southeast of Friendsville; 5 miles southeast of Knoxville; 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville; 1 mile northeast of Friendsville.

Fetzer tongue in Tennessee: At the road bend 0.6 mile south-southeast of Harrison-Chilhowie Academy, Walden Creek (T.V.A. 156-SW) Quadrangle; 1.3 miles south of Sevierville, Pigeon Forge (T.V.A. 156-SE) Quadrangle.

Arline formation in Virginia: In the quarry at Marion, Marion (T.V.A. 218-SE) Quadrangle.

Discussion.—This species is characterized by moderate size, thin shells, fairly strongly resupinate profile, and generally a somewhat narrowly rounded anterior margin as well as a wide and often alate hinge and cardinal extremities. It differs from *P. subtransversa* in its more elongate outline and from *P. resupinata* in its thinner shell, generally smaller size, and more narrowly rounded anterior margin.

PALAEOSTROPHOMENA SUBTRANSVERSA Cooper, new species

Plate 168, C, figures 11-23

Shell wider than long, with the contour of *Strophomena*; cardinal extremities acutely angular, auriculate; anterior margin broadly rounded; lateral margins

oblique; posterior margin nearly straight. Shell multicostellate with about 11 of the primary and intermediate costellae in 1 mm. at the front of a large adult. In the younger stages the surface is marked by numerous primary and intermediate costellae. Very fine costellae occupy the spaces between the larger costellae. Obscure oblique wrinkles occur just anterior to the posterior margin.

Pedicle valve nearly flat in lateral profile, the posterior third to half very slightly convex and the anterior portion very gently concave. About the posterior half of the valve representing the shell up to the stage when it had reached 5 mm. in length is slightly swollen in the umbonal and median region. Anteriorly and anterolaterally of this convex stage the valve is very gently concave. The front portion is usually flattened, but the anterolateral portions are generally deflected slightly in the direction of the pedicle valve. Interarea nearly flat, strongly apsacline. Deltidium long and narrow.

Brachial valve moderately to deeply concave in the median and umbonal portions; concavity extending to about or slightly anterior to the middle. Posterolateral areas just anterior to the posterior margin may be flattened or gently concave. Lateral and anterolateral areas gently convex with gentle slopes to the margins. Anterior slope gentle. Cardinal angles flattened to moderately convex with moderate slopes to the margin. Interarea short, anacline; chilidium short, strongly arched.

Interior of pedicle valve with stout double teeth, no dental plates, wide and moderately long muscle field; diductor scars elongate and with thickened callosity at their anterior ends; pallial marks strong.

Brachial valve having moderately elevated septum highest at its anterior end and extending for about two-thirds the length. Brachiphores short and stout. Cardinal process a simple ridge on a stout but not greatly elevated shaft. Secondary ridges from the chilidium are located on each side of the median cardinal process. Pallial sinuses deeply impressed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 11.9 | 11.1 | 15.7 | 21.6 | 2.1 |
| Paratype (111065i) | 9.3 | 8.9 | 15.1 | 19.0+ | 1.8 |

Types.—Holotype: 111065g; figured paratypes: 111065b,c,e,f,h-j; unfigured paratypes: 111065a,d.

Horizon and locality.—Arline formation in Virginia: At the entrance to Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species is characterized by its wide hinge and mucronate cardinal extremities. In this respect it is most like *P. angulata* from which it differs in its much greater size and different proportions. Inside the pedicle valve the muscle scars of *P. angulata* are more clearly defined, the teeth are smaller, and there is a lesser development of the pallial marks.

APATOMORPHA Cooper, new genus(Greek *apate*, deceit; *morphe*, shape)

Like *Palaeostrophomena* internally but having the normal curvature of *Rafinesquina*, i.e., a flat or concave brachial valve. Shells small in the one known species; concavo- to plano-convex with a moderately long apsacline interarea on the pedicle valve and a shorter hypercline interarea on the brachial valve. Surface multicostellate. Pseudodeltidium and chilidium long and narrowly arched.

Pedicle interior with small teeth consisting of an outer tooth and an inner accessory dental process produced on the inside of the delthyrial cavity. Delthyrial cavity moderately deep; false dental plates extended anteriorly as a ridge on the outside of the muscle field. Muscle field fairly large; adjustor scars small, located at the inside base of the false dental plates. Diductor impressions elongate; adductor area small, situated on and beside a low ridge at the very posterior of the delthyrial chamber. Area between diductors and in front of adductors, striated and roughened. Pallial sinuses strongly impressed; vascula media wide and short, consisting of two depressed channels separated by a low ridge; vascula media bifurcating and sending one branch posterolaterally around the subreniform ovarian impression. The other branch extends anteromedially.

Brachial interior with a low median ridge most elevated at its anterior end and extending for more than half the length of the valve. Brachial processes short and stout, orthoid; cardinal process with thickened shaft cemented to notothyrial platform; myophore surface with three ridges, the median ridge forming a high thin septum; the lateral ridges are lower and are given off from the ends of the chilidium. Adductor field small, located posterior to the highest part of the median ridge; anterior adductor impressions the larger and located inside the posterior scars. Pallial trunks with two major branches originating at the inside ends of the anterior adductors and running parallel to the median ridge to its end where they bifurcate. A second branch originates at the place of division between the posterior and anterior adductors and extends anterolaterally for some distance then bifurcates sending one branch posteriorly and the other anterolaterally.

Genotype.—*Rafinesquina pulchella* Raymond = *Apatomorpha pulchella* (Raymond). (See below for reference.)

APATOMORPHA PULCHELLA (Raymond)

Plate 166, A, figures 1-20

Rafinesquina pulchella RAYMOND, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 296, pl. 3, fig. 10, 1928.

Shell rafinesquinoid in plan and profile; moderately thick-shelled; hinge forming widest part; cardinal extremities nearly rectangular to acute. Lateral margins gently convex; anterior margin broadly to narrowly rounded. Anterior commissure rectimarginate. Surface multicostellate; costellae distant, narrowly rounded and appearing in 4 generations. At the front margin of a specimen

10 mm. long about 20 costellae occupy a space of 5 mm. Interspaces marked by minute concentric fila.

Pedicle valve very slightly convex in lateral profile and forming a low arch in anterior profile. Beak inconspicuous; umbo narrowly swollen and extending anteriorly as a low fold to about the middle. Valve gently swollen in the median portion, somewhat flattened at the anterior. Slopes to the lateral margins long and gentle. Interarea fully twice the length of the interarea of the brachial valve. Pseudodeltidium narrowly arched.

Brachial valve gently concave in the posterior half and the greatest concavity is the narrow depression extending anteriorly from the umbo which corresponds to the fold of the pedicle valve. Anterior half flattened or very slightly concave. Anterolateral and lateral areas flattened to very slightly convex. Cardinal extremities deflected slightly toward the pedicle valve. Interarea short, strongly hypercline.

Interior of pedicle valve with widely divergent diductor scars and deeply impressed pallial trunks; brachial valve with moderately elevated median ridge and small adductor field. Cardinal process with bulbous surface facing pedicle valve.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thickness |
|----------|----------------|--------|-----------------|----------|-------------|-----------|
| Hypotype | (110901a)..... | 12.0 | 10.5 | 13.9 | 14.4 | 1.5 |
| " | (110901b)..... | 10.0 | 9.0 | 12.1 | 13.2 | 1.8 |
| " | (110896e)..... | 8.1 | 7.3 | 9.3 | 10.0 | 1.5 |
| " | (110895a)..... | 8.3 | 7.6 | 10.7 | 10.9 | 1.2 |
| " | (110895b)..... | 9.4 | 8.4 | 10.2 | 10.5 | 1.7 |

Types.—Holotype: M.C.Z. 8624; paratype: M.C.Z. 8625; figured hypotypes: 110895a,c, 110896a-d, 110900a-f, 110901a,b; measured hypotypes: 110895b, 110896e.

Horizon and locality.—Base of the Athens formation in Tennessee: At the L. and N. railroad station in Athens, Athens (T.V.A. 125-NE) Quadrangle; above the quarry, 600 feet S. 40° E. of the railroad crossing 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-NE) Quadrangle; Craighead Creek, $\frac{1}{4}$ mile north of Christiansburg, Sweetwater (T.V.A. 131-SW) Quadrangle; road along Meadow Fork just east of its junction with the valley road, 2 $\frac{1}{2}$ miles northeast of Calhoun, Calhoun (T.V.A. 125-SW) Quadrangle; just southeast of the intersection of the valley road and the road up Crouth Hollow, 2 $\frac{1}{2}$ miles south-southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle.

Discussion.—This species was first described as a *Rafinesquina*, but the simple cardinal process, the stout shell, and the form of the pedicle muscles are all unlike that genus. *Apatomorpha* is closest to *Palaeostrophomena* and may be considered as having the same relationship to that genus as *Strophomena* has to *Rafinesquina*. No other species of *Apatomorpha* is now known to which *A. pulchella* may be compared. None of the described brachiopods from Girvan, Scotland, appear to belong to *Apatomorpha*.

Genus **GONIOTREMA** Ulrich and Cooper, 1936

Plate 209, D, figures 14-22

Goniotrema ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 626, 1936; Geol. Soc. Amer. Special Pap. 13, p. 193, 1938.

During the present studies and collecting no more specimens of this interesting brachiopod were found. Cooper visited Ikes Canyon in 1946 in the hope of locating more of this species among other brachiopods but failed. A restudy of the type specimen confirms the presence of the foramen which is much too regular to be a freak of silicification. The muscle scars are long, slender, and divergent and reminiscent of *Sowerbyites*, as is the form and profile of the shell, but the anterior callosities so characteristic of *Sowerbyites* are not present.

The brachial interior is somewhat reminiscent of *Sowerbyites*, but the septa are much more subdued. Restudy of the cardinalia suggests that a mistake in interpretation of the cardinal process was made owing to the silicification. It is probable that the cardinal process is a single piece rather than a lobate form, and the posterior part of it including the median ridge has been worn off. If this interpretation be correct, the cardinal process becomes like that of *Sowerbyites* and the genus should be classified with the Plectambonitacea.

Type.—Holotype: 92872.

Horizon and locality.—Upper Pogonip group in Nevada: In Ikes Canyon, Toquima Range, Roberts Mountains (1°) Quadrangle.

PAUCICOSTELLA Cooper, new genus(Latin *pauculus*, few; *costa*, rib)

Shells thin, generally wider than long, with the hinge forming the widest part; surface covered by two sets of costellae, a group of strong distant costellae in a mat of fine costellae. Faint rugae may mark the posterior margin. Pseudopunctate.

Pedicle interior with short and rudimentary dental plates and large and wide muscle field. Pseudodeltidium short. Brachial interior with delicate cardinalia; flat bladelike brachiophores; small notothyrial platform; median ridge short and thick, not connected conspicuously with notothyrial platform. Cardinal process not seen, probably absent. Chilidium thin, strongly arched.

Genotype.—*Paucicostella canadensis* Cooper, new species.

Discussion.—This genus is based on a species whose details are difficult to ascertain. The specimens occur as separated valves in a fairly soft granular limestone. The shells are so thin that the usual method of burning the shell and then developing the interior by use of needles failed to produce useful brachial interiors, but the nature of the dental plates was determined. The interior features of the brachial valve recorded above were obtained by etching the exterior of the brachial valve with weak acid and interpreting the structures as seen in the wet specimen.

The interior details are suggestive of those of *Ptychoglyptus* and *Glyptambonites*, but the ornamentation sets *Paucicostella* off from both of those genera.

PAUCICOSTELLA CANADENSIS Cooper, new species

Plate 172, A, figures 1-6; plate 173, D, figure 24

Wider than long, cardinal extremities nearly a right angle or acute; sides nearly straight or sloping toward the middle; anterior margin broadly rounded; surface costellate, large costellae numbering 8 or 10 on each side of the median line and appearing in 2 generations; fine costellae covering entire surface, 6 or 7 in 1 mm. at the front margin.

Pedicle valve unevenly convex, with the convexity strongest at the umbo, the median region somewhat flattened and the anterior part depressed toward the brachial valve; anterior profile broadly and slightly convex. Umbo somewhat narrowly swollen but not extended far forward. Median region flattened to concave; anterior quarter or third depressed to form a shallow, wide sulcus. Flanks bounding sulcus flattened.

Brachial valve nearly flat in lateral profile; same in anterior profile; umbo concave, the concavity short and shallow; median region slightly inflated, the swelling produced to the anterior margin to form a barely perceptible, broad fold; flanks bounding fold flattened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 8.0 | ? | 11.9 | 11.7 | ? |
| Paratype (" " 117395f) ... | 7.8 | ? | 13.4 | 13.1 | ? |
| " (" " 117395g) ... | 6.7 | ? | 10.7 | 11.0 | ? |
| " (brachial valve 117395d) .. | ? | 7.6 | 12.6 | 12.5 | ? |
| " (" " 117395e) .. | ? | 7.5 | 10.1 | 11.9 | ? |
| " (" " 117395p) .. | ? | 8.1 | 11.0 | 11.9 | ? |
| " (" " 117395q) .. | 7.0 | 7.0 | 11.3 | ? | 1.1 |

Types.—Holotype: 117395b; figured paratypes: 117395a,c-f, 117394b; unfigured paratypes: 117394a, 117395g-w.

Horizon and locality.—Boulder in Mystic conglomerate in Quebec, Canada: In Range 6, Lot 21, 2.6 miles north and $\frac{1}{2}$ mile east of Mystic, Stanbridge Township; Range 6, Lot 20, same township.

Table Head series (upper) in Newfoundland: At Table Point Cove.

Discussion.—No other species of this genus is known to which this one can be compared.

GLYPTAMBONITES Cooper, new genus(Greek *glyptos*, engraved; *ambon*, umbo)

Suggesting *Rafinesquina* sensu stricto in outline and profiles. Pedicle valve gently convex in lateral profile, brachial valve flat or very slightly concave. Shells of large size. Surface marked by a few strong costellae in a field of very fine costellae, strong oblique wrinkles marking the shell just below the posterior margin and on each side of the beak.

Pedicle valve with teeth small and simple, like those of the orthids; dental plates short, produced forward as a low ridge on the outside of the muscle field,

which is small and elongate. Diductor-adjustor scars subequal, elongate, narrow, extended anterior to delthyrial cavity; adductor field confined to delthyrial cavity.

Cardinalia most suggestive of *Sowerbyites* with long, slender brachial processes supported in part by callus deposited under the cardinal process and their inner surfaces. Cardinal process tripartite, with a median elevated ridge and two lesser ridges on each side of it and separated by deep grooves. Face of cardinal process toward the pedicle valve somewhat bulbous. Median septum thin, most elevated at its anterior part, not reaching posteriorly to the cardinal process. Adductor field small.

Genotype.—*Glyptambonites musculosus* Cooper, new species.

Discussion.—The shells of *Glyptambonites* are unusually beautiful with their varied radial costellae and the oblique wrinkling of the hinge. The genus also attains a large size for an early Paleozoic brachiopod. The interior details are similar to those of *Palaeostrophomena* but the habit and profile are different from those of that genus, which has a resupinate lateral profile.

Although the interior details are like those of *Palaeostrophomena*, some features are differently developed than in that genus. The diductor scars are usually much longer and more slender than in *Palaeostrophomena*. The adductor field is enclosed deeply by the diductors, and the space between the diductors and anterior to the adductor field is occupied by a longitudinally striated and granulose area. The ovarian impressions are not as proportionately large as those of *Palaeostrophomena*. Inside the brachial valve the brachioophores are more delicate than those of *Palaeostrophomena* and the adductor field is smaller. The pallial marks of both valves are similarly arranged to those of *Palaeostrophomena*.

GLYPTAMBONITES GLYPTUS Cooper, new species

Plate 168, A, figures 1, 2; plate 173, C, figures 13-23; plate 175, A, figures 1-8

Shell semielliptical in outline, wider than long, thin, concavo-convex. Lateral margins slightly rounded; anterior margin broadly rounded. Cardinal extremities narrow acute to mucronate in the young but only slightly auriculate in the adult and old shells. Surface ornamented by costellae of different sizes, from 5 to 7 of the stronger costellae mark the umbonal region and the young stages, but in growth, costellae of intermediate size are intercalated between the primary ones and the finest costellae, covering the whole surface. Total strong costellae at the front margin about 20. Median costella usually the strongest of them all. Very fine costellae from 5 to 7 in a millimeter occupy the spaces between the stronger ones. Very fine concentric fila cancellate the fine costellae. Posterolateral region marked by strong oblique wrinkles and in the posterior quarter to half of the valves transverse wrinkles may undulate the sectors of shell marked out by the major costellae, these portions of the valve often suggesting the genus *Ptychoglyptus* in ornamentation.

Pedicle valve very slightly convex in lateral and anterior profiles. Central and posteromedian parts of the valve slightly swollen but the anterior, lateral, and

posterolateral regions flattened. Beak small and protruding slightly beyond the posterior margin. Interarea flat, short, with narrowly rounded pseudodeltidium.

Brachial valve gently concave in lateral profile; umbo concave, small; posterior part of valve nearly flat to very gently concave; median region slightly concave. Lateral and posterolateral regions flattened. Interarea short, anacline to hypercline. Chilidium moderately large.

Interior of pedicle valve with moderately deep delthyrial cavity; dental plates mere remnants, divergent, with anterior ends thickened into false plates extending anteriorly around the outside margins of the muscle field. Teeth small, simple. Muscle field small, narrow; diductor impression elongate, narrow, extending far anterior to the front of the delthyrial chamber. Adductor impressions confined to delthyrial chamber and placed far back, separating the posterior ends of the diductor impressions.

Brachial valve with cardinal process having a strong median carina and smaller lateral accessory septa. Chilidium projecting over posterior half of cardinal process; cardinal process protruding in the direction of the pedicle valve and overhanging thickened area posterior to median septum. Brachial processes thin, short, widely divergent. Median septum short, thin, elevated at its anterior end. Adductor field subflabellate.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------|--------|--------|-------------|-----------|
| Holotype | 22.3 | 29.9 | 31.4 | ? |
| Paratype (123250a) | 12.2 ? | 15.8 ? | 22.7 | ? |

Types.—Holotype: 117383a; figured paratypes: 117385b, 117386a-d, 117387a-g, 123248a,b, 123250b; unfigured paratypes: 117383b-l, 117384a-e, 117385a, 123250a,c-g.

Horizon and locality.—Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle.

Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Botetourt formation in Virginia: At the junction of Virginia County Highways 731 and 724, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Discussion.—This species is based on few adult specimens. Most of the material consists of young forms some of which have been dissolved out of limestone and show the interiors to perfection. The adult is characterized by rather distant strong costellae at the front margin and a modest wrinkling on the posterior margin near the umbo. In *G. musculosa* the ornamentation has more

closely spaced strong costellae in the adult stages and the wrinkling on the posterior margin is strong and extends along nearly the entire shell width.

GLYPTAMBONITES MUSCULOSUS Cooper, new species

Plate 171, B, figure 15; plate 175, B, figures 9, 10; plate 175, C, figures 11-13;
plate 176, A, figures 1-5

Shell large, plano- to concavo-convex, with the hinge forming the widest part; sides gently rounded and sloping inward somewhat obliquely; anterior margin broadly rounded. Cardinal extremities acute to mucronate. Posterior margin nearly straight. Surface finely costellate, costellae of two sizes and consisting of large primary and secondary, tertiary and quaternary costellae in a mat of extremely fine costellae. Five or six of the larger costellae occupy a space of 5 mm. at the front of a valve 19 mm. long. Fine costellae cancellated by moderately strong concentric fila. Posterior margin and umbolateral slopes strongly wrinkled.

Pedicle valve evenly and faintly convex in anterior and lateral profiles; umbo and median regions faintly swollen; area in front of cardinal extremities gently concave. Interarea about twice as long as the brachial one; pseudodeltidium narrowly swollen.

Interior with elongate diductor scars extending nearly to the middle of the valve; adductor impressions forming a small oval patch located in the apical angle formed by the long diductors; area immediately anterior to adductor scars and between diductors strongly granulose; teeth moderately strong, double as in *Palaeostrophomena*; false dental plates thick; ovarian impression a triangular area of wavy lines and granules in the angle formed by the palintrope and the false dental plates. Pallial marks prominent, the trunks narrow and numerous, each trunk formed of two channels, thin and deep, separated by a low ridge.

Complete brachial exterior not yet known but a single impression of the brachial interior indicates a nearly flat valve with hypercline interarea and narrowly elevated chilidium. Interior with short and delicate brachiophores partially buried in the tissue of the notothyrial platform; cardinal process with short shaft, bulbous at its posterior end and with triseptate myophore, the median ridge of which is strongly elevated, adductor field forming an inverted pentagon bisected by a moderately strong but low median ridge; anterior adductors smaller than the posterior pair and forming the apex of the pentagon. Pallial marks prominent, two trunks coming off the inside ends of the anterior adductors and extending anteriorly along each side of the median ridge; a second pair of trunks originates at the line of junction of the adductor scars and extends anterolaterally. Ovarian impressions moderately large.

Measurements in mm.—

| | Length | Midwidth | Hinge width |
|--------------------------|--------|----------|-------------|
| Holotype | 25.4 | 33.2 | 37.0+ |
| Paratype (117390d) | 18.7 | 26.0 | 35.0 |
| " (117388b) | 17.6 | 24.5 | 27.0+ |

Types.—Holotype: 117390c; figured paratypes: 117388c,d, 117390a, 117391; unfigured paratypes: 117388a,b, 117390b,d-n.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle; on the Bowman Farm, $\frac{1}{4}$ mile east of U. S. Highway 11, about 1 mile southwest of Woodstock, Edinburg (15') Quadrangle; just west of the junction of County Highways 617=910, and 777 about $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle. In Strasburg (15') Quadrangle: on U. S. Highway 11, $\frac{1}{2}$ mile south-southwest of Tumbling Run, southwest of Strasburg; on Virginia Highway 55, 0.4 mile west of U. S. Highway 11, north edge of Strasburg (type section of Oranda formation); on U. S. Highway 11, 1 to $1\frac{1}{2}$ miles southwest of Strasburg; along the railroad $\frac{1}{2}$ mile west of Strasburg.

Discussion.—Good specimens of this species are hard to obtain. The shell was apparently a fragile one and was easily broken up. It is also an odd fact that the brachial valve is exceptionally rare. A single specimen only was obtained. This species is characterized by its large size and beautiful ornamentation. In comparison to *G. glyptus* it has more of the larger costae at the front margin than does the *Effna* form.

GLYPTAMBONITES ? PLATYS (Butts)

Sowerbyella platys BUTTS, Virginia Geol. Surv. Bull. 52, p. 200, 1940; *ibid.*, p. 109, pl. 95, fig. 17, 1942.

This is a small specimen of poor preservation and uncertain generic characters. It is a young specimen, besides, whose generic affinities cannot be established from exterior examination. It might belong to *Palaeostrophomena* or possibly *Glyptambonites*, in which it is here provisionally placed. The specimen is actually not adequate for a specific diagnosis. It has nothing to do with *Sowerbyella* which has a strongly convex pedicle valve.

The specimen is 5.9 mm. long and 10.4 mm. wide at the hinge. The sides slope obliquely toward the middle, and the front margin is broadly rounded. Cardinal extremities acute. Pedicle interarea long, apsacline; interarea of the brachial valve short and hypercline. Surface marked by three generations of strong costellae in a mat of fine costellae. Pseudodeltidium and chilidium narrowly rounded and elongate as in *Palaeostrophomena* and *Glyptambonites*.

Horizon and locality.—The stratigraphic position of this specimen is not certainly known. A label in Butts' handwriting states "Strasburg No. 7." This suggests that it is bed 7 of Ulrich's section along the railroad tracks just east of Strasburg Junction (or $\frac{1}{2}$ mile west of Strasburg). If this is the correct interpretation of the label, the specimen came from the Edinburg formation (*Cyrtontella* zone). The matrix on the specimen is in accord with this designation. This would be bed c of the geologic section in the vicinity of Strasburg. (Bassler, 1909, p. 56.)

TITANAMBONITES Cooper, new genus(Greek *titan*, large; *ambon*, umbo)

Shells usually large, generally more than an inch wide; concavo-convex and resembling *Sowerbyites* in exterior details: Costellae fine, distant, crossed by prominent concentric fila. Shell substance pseudopunctate.

Pedicle interior with large, flat, oblique teeth having a deep crural fossette; dental plates absent; muscle field large, resembling *Sowerbyites* with long diductor scars extending to the middle or beyond and lying at the base of large callosities; adjustor scars long and slender, located posterolaterally to the diductors; adductors constituting a small somewhat rectangular patch just anterior to the posterior junction of the diductors; ovarian impressions small. Pallial impressions prominent, vascula media extending anteromedially from anterior end of diductor scar and occupying the callosity at the end of the diductor scar; minor distributaries occupying the inside of the trail. Pseudodeltidium a long, narrow arch.

Brachial valve with low median septum not prominent anterior to the cardinalia but rising to a crest anteriorly and partitioning the shell cavity where the trail is geniculated from the body. Brachioophores small, short, divergent; cardinal process a boss excavated on the side facing the anterior but with a trisep-tate myophore, the median ridge being the highest; chilidium narrowly convex, arched over proximal end of cardinal process; cardinal process supported by shell substance deposited between the brachial process and the side of the cardinal process. Adductor field small, the posterior adductors the larger; pallial trunks strongly impressed, a large trunk extending anteriorly on each side of the median ridge and another major trunk extending anterolaterally from place of junction of anterior and posterior adductor pairs. Ovarian impressions moderately well developed.

Genotype.—*Titanambonites medius* Cooper, new species.

Discussion.—The members of this genus are fairly easy to recognize because of their general resemblance to *Sowerbyites*. They are, however, usually much larger than any known members of that genus and the brachial valves are very different. *Titanambonites* has an interesting ornamentation which is unlike the usual plectambonitids in not having the fine matrix of extremely small costellae. In the genus under consideration the costellae are moderately distant and appear in several generations. They are crossed by fine but prominent concentric fila which cover the whole shell. In this respect *Titanambonites* resembles the Estonian genera *Leptestia* and *Ingria*. In this respect, too, it is unlike *Sowerbyites*.

The pedicle interior contains a number of interesting anatomical features. Dental plates are absent, but the spaces between the palintrope and the inner shell surface are the sites of thick shell deposit, so thick in some specimens that the shell material protrudes anterior to the margin of the palintrope to form a slightly oblique ridge. The muscle field with its prominent callosities anterior to the diductor scars is very suggestive of *Sowerbyites*. The callosities are usually very

strong, and the *vascula media* take their origin at the anterior end of the diductor muscle on the callosity. Another pallial trunk of importance originates at the anteromedian edge of the ovarian impression. The latter are small and seem to be better developed in the pedicle than the brachial valve.

The cardinal process is of interest because it seems to have no shaft or at least a minimum development of that structure. The process arises abruptly from the notothyrial platform and extends toward the pedicle valve. Its anterior face is somewhat excavated but the myophore bears 3 prominent septa. The cardinal process is reinforced by shell material deposited on the inside of the brachio-phores, giving the appearance of the latter structures being welded to the cardinal process. It does not, however, present the tentlike, deeply excavated plate of *Sowerbyella*. The brachio-phores are short and inconspicuous rods. The median ridge is low in the adductor field but is elevated at its anterior end and must have partitioned the anterior of the shell cavity into two chambers. As in the pedicle valve the brachial valve has a thickening of shell material laid more or less parallel to the posterior margin and just anterior to it. This taken in conjunction with the ridge of the pedicle valve may have helped in shell articulation.

Titanambonites is most like *Sowerbyites* of American genera. The pedicle valves of the two genera are very close, but the brachial valves are quite different. In *Titanambonites* no lateral septa have yet been observed, and the form of the median ridge is different. Of European genera *Leptestia* is most like *Titanambonites*. In the case of *Leptestia* differences occur inside both valves. *Leptestia* has a small delthyrial cavity to which the muscle scars are confined. This cavity is bounded by ridges suggestive of dental plates but possibly of different origin. Anterior to the muscle field is a low median ridge which separates two exceptionally large subreniform ovarian impressions. The brachial valve of *Leptestia*, too, is characterized by an exceptionally large subreniform ovarian impression occupying most of the shell surface. The median septum of *Leptestia* is more elevated than that of *Titanambonites*, and the cardinal process has a pronounced shaft. The myophore, chilidium, and adductor field are like those of the American genus.

TITANAMBONITES AMPLUS (Raymond)

Plate 177, A, figures 1-10; plate 179, A, figures 1-6; plate 180, B, figures 14-16;
plate 194, B, figures 11-18; plate 206, C, figure 13

Plectambonites amplus RAYMOND, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6,
p. 297, pl. 2, fig. 9; pl. 3, fig. 12, 1928.

Large for the genus, wider than long and with the hinge forming the widest part; sides sloping slightly obliquely toward the middle; anterior margin broadly rounded. Costellae low, thin, rounded, and distant, about 2 or 3 to the millimeter; concentric fila strong.

Pedicle valve strongly convex in lateral profile, fairly strongly domed in anterior profile; beak scarcely protruding posterior to the posterior margin; umbo moderately swollen, marked by a narrow, short fold at the beak; median region

strongly swollen, with steep slopes in all directions; anterior slope the steepest. Pseudodeltidium narrow; interarea long, orthocline. Interior with short, flat teeth; callosities appearing on each side of teeth and extending parallel to hinge; diductor scars long, extending to the middle and ending on high callosities; pallial marks strongly developed.

Brachial valve closely following the curvature of the pedicle valve, most concave in the median region; umbo concave, the concavity continued anteriorly as a shallow sulcus to a point anterior to the middle; interarea moderately long, hypercline. Interior with well-marked but low median septum in the young; old adults with septum obscured by adventitious shell; adductor impressions small; pallial trunks well developed; ovarian impressions moderately large, marked by fine, wavy lines; brachioophores small; callosity parallel to edge of palintrope separated from hinge margin by groove.

Measurements in mm.—

| | Length | Brachial length | Surface length | Midwidth | Hinge width | Thickness |
|------------------------|--------|-----------------|----------------|----------|-------------|-----------|
| Hypotype (117421)..... | 23.6 | 20.1 | 30.5 | 29.1 ? | 33.0 ? | 4.6 |
| " (117422)..... | 25.1 | ? | 35.0 | 37.6 | ? | ? |
| " (117418)..... | ? | 23.9 | ? | 37.9 | ? | ? |

Types.—Figured hypotypes: 117416, 117417, 117418, 117420a, 117421, 117422, 117423b.

Horizon and locality.—Arline formation in Tennessee: 6 miles southeast of Knoxville; north side of old wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; McMullens, Meadow (T.V.A. 139-NW) Quadrangle; at the Gulley Cemetery, 0.4 mile northeast of St. Clair, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Fetzer tongue in Tennessee: At the bend of the road 0.6 mile south-southeast of Harrison-Chilhowie Academy, Walden Creek (T.V.A. 156-SW) Quadrangle.

Little Oak formation in Alabama: On the point of the ridge, 1 mile southwest of Newhope Church, Vandiver (15') Quadrangle; 2 miles north of Pelham, Bessemer Iron District (15') Quadrangle; cut on the L. and N. RR., $\frac{3}{4}$ mile northwest of Mosteller, Columbiana (15') Quadrangle.

"Lenoir" formation=Little Oak in Alabama: East of Leeds, Leeds (15') Quadrangle.

Pratt Ferry formation: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This is the largest and most robust of the species of this genus. A few specimens only are known, but these show the species to be somewhat variable in its convexity. Beside its great size this species differs from the others described in the evenness of its lateral profile.

TITANAMBONITES CONVEXUS Cooper, new species

Plate 178, A, figures 1-8

Shell of about medium size for the genus, wider than long, with the hinge equal to or wider than the width at the middle; sides sloping by a gentle curve

toward the middle; anterior margin broadly rounded; surface distantly costellate and with fine concentric fila.

Pedicle valve strongly convex in the median and anterior regions when viewed in lateral profile; anterior profile strongly domed; beak small; fold low and inconspicuous, extending from the beak to the middle; posterior third gently convex; median third strongly swollen and anterior third moderately convex; anterior slope steep, much steeper than the longer posterior slope. Interior as usual for the genus.

Brachial valve gently concave in the posterior half, strongly concave in the anterior half. Umbo concave; sulcus narrow and shallow, disappearing at or near the middle; interarea long, hypercline.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 17.3 | 14.2 | ? | 24.4 | 25.3 | 5.0 | 7.3 |
| Paratype (117424a) .. | 17.8 | 13.7 | 24.0 ? | 23.5 | 25.4 | 5.5 | 7.9 |
| " (117424d) .. | 16.7 | 14.2 | 22.5 | 21.0 | 22.0 | 4.6 | 6.8 |

Types.—Holotype: 117424e; figured paratypes: 117424b,d; unfigured paratypes: 117424a,c.

Horizon and locality.—Little Oak formation in Alabama: At the junction of the Bailey Gap and Cahaba Valley roads, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle; quarry north of Pelham, Bessemer Iron District (15') Quadrangle.

Discussion.—This species has about the same size and proportions as *T. crassus* (Willard) but differs in having a more convex posterior half, a more rounded geniculated part with a higher but less steep anterior slope. The brachial valve of *T. convexus* is somewhat deeper than that of the Effna species.

TITANAMBONITES CRASSUS (Willard)

Plate 181, A, figures 1-9

Plectambonites crassus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 278, pl. 3, fig. 10, 1928.

Outline subrectangular, wider than long, hinge forming widest part. Lateral margins sloping gently inward, nearly straight. Anterior margin gently and broadly rounded. Surface costellate; distantly spaced larger costellae separated by numerous finer ones. The larger costellae in the exfoliated condition have the appearance of being double.

Pedicle valve gently convex in posterior three-quarters but strongly geniculated in the anterior quarter. Point of geniculation about 16 mm. anterior to beak; angle of geniculation about 110°. Beak short, barely protruding posterior to the posterior margin. Umbo slightly swollen and melting into the low convexity of the median area; lateral areas flattened to slightly concave. Anterior slope steep, the steepness decreasing posterolaterally as the length of slope declines. Geniculated slope flat in profile. Interarea long, apsacline.

Brachial valve with umbo a fairly deep pit and with interarea overhanging the exterior slightly. Umbonal pit continued anteriorly for a quarter the length of the valve as a shallow depression. Areas flanking this depression slightly concave; posterolateral extremities flattened. Geniculated area nonexistent at the cardinal extremities but rising medially to form a prominent anterior boundary to the concave valve. Interarea fairly long, hypercline.

Interior of pedicle valve with elongate diductor impressions and strong terminal callosities. Interior of brachial valve with strong median ridge extending anteriorly to the place of geniculation. Adductor field small. Inner marginal ridges strong.

Measurements in mm.—Hypotype (117425a), length 20.3, width 16.7, hinge width 21.4+, thickness 5.0.

Types.—Figured hypotypes: 117425a-c,e.

Horizon and locality.—Effna formation in Virginia: At McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—In size and general appearance this species suggest *T. medius* Cooper, but sufficient differences in ornamentation and exterior shape can be seen to establish their identity. The angle of geniculation of this species is smaller than that of *T. medius*, and the geniculated portion is less convex and the angularity more distinct. Although the details of the ornamentation of *T. medius* cannot be determined accurately with the material at hand, the species does not seem to have the strong concentric elements that are so conspicuous in *T. medius*. Furthermore, the double character of the larger costellae was not detected in the other species.

TITANAMBONITES MEDIUS Cooper, new species

Plate 178, B, figures 9-21; plate 185, B, figures 11-13

Shell large for the genus, semielliptical in outline, wider than long. Cardinal extremities acute. Shell widest at or just anterior to the hinge. Lateral margins nearly straight, sloping medially; anterior margin broadly rounded. Surface multicostellate. Costellae distant, about 13 in the space of 5 mm. at the front margin. Costellae and interspaces covered by fine, elevated, concentric fila, about 10 in the space of 1 mm., a strong median costella marking both valves.

Pedicle valve unevenly convex in lateral profile, the umbonal region moderately convex, the body of the shell gently convex and the geniculated portion fairly convex. Angle of geniculation 115° to 120° and geniculation taking place about 17 mm. anterior to the beak. Anterior profile broadly convex. Umbonal region narrow at the beak, widening anteriorly at median swollen area. Median region somewhat swollen. Posterolateral slopes gently concave to the cardinal extremities. Anterolateral and anterior slopes steep. A slight fold may be developed on the geniculated third. Interarea orthocline to apsacline, fairly long and only slightly curved. Pseudodeltidium narrowly elevated.

Brachial valve concave and fitting closely into opposite valve. Umbonal region a moderately deep pit widening anteriorly into a median area that is some-

what more depressed than the surrounding valve. Anterior median third slightly sulcate. Areas flanking median depression more gently concave. Interarea hypercline, plane.

Interior of pedicle valve with strong, flat teeth supported by callus and set somewhat obliquely to the delthyrial edge. Muscle area large with elongate, divergent diductor scars terminating in prominent anterior callosities. Adductor scars show as small pits located at the angle of divergence of the diductors. Adjustors shorter than the diductors, long and narrow and located along the inner margins of the delthyrial cavity. Pallial impressions strong, the major trunks bifurcating at the anterior ends of the diductors and splitting into many small channels anteriorly.

Interior of brachial valve with short brachiophores; cardinal process a simple boss welded with the chilidial plates to form a single piece overhanging a pit at the posterior end of the median septum. Median septum extending slightly anterior to the middle, elevated in front and flanked by shorter septa on each side.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Surface length | Thickness | Height |
|-----------------------|--------|-----------------|-----------|-------------|----------------|-----------|--------|
| Holotype | 18.6 | 16.1 | 24.4 | 22.3 ? | 23.8 | 3.7 | 6.6 |
| Paratype (117429a) .. | 20.1 | ? | 27.5 | 30.0 | 25.0 | ? | ? |
| " (117429i) .. | 18.9 | 15.5 | 24.3 | 25.2 | 22.5 | 4.1 | 6.4 |
| " (117428) ... | 18.8 | 15.0 | 22.1 | 22.8 | 22.5 | 4.3 | ? |

Types.—Holotype: 117426b; figured paratypes: 117426a, 117429a-g; unfigured paratypes: 117428, 117429h,i.

Horizon and locality.—At the base of the Athens formation (with *Christiania*) in Tennessee: 1.9 and 2.5 miles northeast of Christiansburg, Sweetwater (T.V.A. 131-SW) Quadrangle; Craighead Creek, $\frac{1}{4}$ mile north-northwest of Christiansburg, Sweetwater (T.V.A. 131-SW) Quadrangle; Fetzer tongue, south side of the road 200 yards southwest of Blockhouse, Blockhouse (T.V.A. 148-NW) Quadrangle.

Discussion.—This species is characterized by its size intermediate between *T. amplus* and the smaller species. It is very close to *T. praecursor* of the Lenoir formation but differs in the shape and convexity of the valves. *Titanambonites medius* is usually moderately acuminate at the cardinal extremities whereas *T. praecursor* has rounded rather than oblique sides and the cardinal extremities are a right angle or slightly obtuse. The lateral profile of *T. praecursor* is less full than that of *T. medius*.

TITANAMBONITES PRAECURSOR Cooper, new species

Plate 184, D, figures 6-12

Large for the genus, subrectangular in outline with the width greater than the length; cardinal extremities nearly a right angle; sides gently rounded; anterior margin strongly rounded; ornamentation consisting of narrow, distant threadlike costellae, covered by strong concentric fila.

Pedicle valve moderately convex in lateral profile, moderately domed in an-

terior profile; umbo moderately swollen and somewhat narrowed at the beak; median region moderately swollen and with steep anterior and posterior slopes of about equal proportions; lateral slopes moderately long and moderately steep; interarea long and orthocline. Interior with narrow diductor scars and moderately large callosities at, or slightly anterior to, the middle.

Brachial valve moderately concave, maximum concavity anterior to the middle; umbo concave, the concavity produced anteriorly nearly to front margin as a shallow, poorly defined sulcus. Flanks bounding sulcus in posterior somewhat flattened. Anterior third fairly strongly geniculated. Interior with short blade-like brachiophores and thick cardinal process; median ridge low, elevated anteriorly; adductor field small. Pallial trunks moderately impressed.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Surface length | Thickness | Height |
|----------------------|--------|-----------------|-----------|-------------|----------------|-----------|--------|
| Holotype | 20.9 | 17.3 | 27.0 | 28.4 | 25.5 | 5.0 | 6.9 |
| Paratype (117430)... | 21.5 | 18.6 | 27.4 | 29.2 | 25.6 | 4.4 | 6.4 |

Types.—Holotype: 117431a; figured paratypes: 117431b,c; measured paratype: 117430.

Horizon and locality.—Lenoir formation (base of *Billingsaria* zone) in Tennessee: On both sides of east-west road leading into marble quarry, 1 mile north-east of Friendsville, Concord (T.V.A. 138-SE) and Louisville (T.V.A. 138-SE) Quadrangles.

Discussion.—For differences between this species and *T. medius* see discussion under that species.

TITANAMBONITES sp. 1

Plate 177, B, figure 11

This is a large specimen coming from the massive limestone above the *Mac-lurites* beds and below the Pratt Ferry formation, which approaches *T. amplus* (Raymond) in size but is shorter, more rounded in lateral profile, and seems to have a greater height than specimens from McMullens, Tenn.

Figured specimen.—117432.

Horizon and locality.—"Lenoir" (part with *Christiana*=Little Oak) in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Genus SOWERBYITES Teichert, 1937

Sowerbyites TEICHERT, Rep. 5th Thule Exped., 1921-24, vol. 1, No. 5, p. 66, 1937.

Externally like *Sowerbyella* forming a semicircle in outline, interareas well developed on both valves; hinge wide; surface marked by costellae of two sizes. Delthyrium partially closed by a rudimentary pseudodeltidium.

Pedicle interior with muscle field occupying most of the median portion of the valve. Diductor impressions divergent, exceptionally long, extending anterior to the middle. Adductor impressions small, located within the delthyrial cavity. Adjustor impressions located outside the diductors, elongate, separated from them by a more or less well developed ridge. Teeth moderately large, composed

of two parts: an outer tooth flush with the interarea and situated at the angle between the delthyrial margin and the edge of the palintrope, and an inner tooth lying under the outer tooth. At the anterior ends of the diductor-adjustor scars is a thick callus deposit bearing the proximal ends of the pallial trunks. One main trunk extends from the anterolateral edge of the diductor impressions and two extend from the end of the probable adjustor impressions. Ovarian impressions well developed, subtriangular in outline and located between the muscle field and the cardinal angles.

Cardinalia small but strong; cardinal process a simple ridge highest in the direction toward the pedicle valve and descending toward the brachial valve. Chilidial plates thick but low. Brachial processes short, flat blades widely divergent and supported by callus which welds the cardinal process and chilidial plates together. Median callus deposit extending forward to the point of origin of median septum which it partially surrounds. Median septum extending to beyond the middle where the valve is geniculated, expanded at its distal extremity. A shorter septum occurs on each side of the median septum, which divides one set of adductors (?) from the others. Muscle scars 6 in number, 2 occupying the areas anterior to each brachial process and outside the accessory septa, 1 located between the accessory septa and the median septum. Ovarian impressions, subreniform in outline, occupy the region between the muscle field and cardinal angles. One main pallial trunk extends from the single muscle scar, and a large divided trunk extends anteriorly from the outside scars.

Genotype.—*Sowerbyites medioseptata* Teichert, Rep. 5th Thule Exped., 1921-1924, vol. 1, No. 5, p. 66, pl. 12, figs. 16, 17, 1937.

Discussion.—This genus was described by Teichert from the "Trenton" of Melville Peninsula, Arctic Canada. Although Dr. Teichert described and figured the brachial valve well, the interior of the pedicle valve was unknown. Excellent specimens of this genus from the Lincolnshire formation of the Southern Appalachians and the Bromide formation of Oklahoma here figured give much added information. The median septum of the brachial valve is the most important feature of the genus, but the callosities at the anterior ends of the muscle scars of the pedicle valve are likewise very characteristic and aid in quick identification of the genus.

Besides the median septum a number of other significant differences from *Sowerbyella* may be pointed out. In the pedicle valve of *Sowerbyella* a short but prominent median septum divides the posterior portion of the muscle area. Furthermore, the muscle scars of this valve are seldom, if ever, as long as in *Sowerbyites* and are generally much more divergent.

The cardinalia of *Sowerbyella* show important differences from those of *Sowerbyites*. The brachial process of the latter is much shorter and stouter than that of *Sowerbyella*. The cardinal process of *Sowerbyella* is generally smaller but is joined to the brachial processes and chilidial plates in much the same manner as in *Sowerbyites*. The major difference is in the incomplete deposition of callus over the cardinal structures. In *Sowerbyella* a deep cavity exists under

the cardinal process. The median septa extend nearly but not quite into the cavity.

SOWERBYITES DELICATUS Cooper, new species

Plate 179, B, figures 7-20

Shell of about medium size for the genus, wider than long, length about two-thirds the width; cardinal extremities approximately a right angle and slightly auriculate; sides gently convex; anterior margin broadly rounded; ornamentation as in other species but very fine; about 10 of the larger costellae occupy 5 mm. at the front margin. Lamellae poorly preserved, observed mostly near the front margin.

Pedicle valve moderately convex in lateral profile and with the maximum convexity slightly anterior to the middle; anterior profile broadly convex and slightly humped in the median region; umbo narrowly swollen to form a low fold that extends more or less distinctly to the middle or slightly beyond; median region swollen; flanks gently convex and with long, gentle slopes to the margins; anterior slope moderately long and moderately steep. Interarea long, apsacline.

Brachial valve concave, with the maximum concavity just anterior to the center; umbo concave, the concavity extending nearly to the middle as a shallow and narrow sulcus; flanks gently concave; interarea short, hypercline.

Interior of pedicle valve with moderately strong callosities at the anterior ends of the diductor scars; pallial marks not pronounced. Interior of brachial valve with small and short brachial processes; median septum strongly elevated and thickened at the front; outside pair of lateral septa poorly developed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 10.9 | 9.8 | 14.2 | 14.2 | 1.9 |
| Paratype (117399d) | 9.9 | 8.8 | 14.7 | 16.2 | 1.7 |

Types.—Holotype: 117399e; figured paratypes: 117399a-d,f-h.

Horizon and locality.—Low in the Sevier shale in Tennessee: 1.8 miles S. 18° E. of Athens, Athens (T.V.A. 125-NE) Quadrangle.

Discussion.—This species has been found only at a single locality where it occurs in countless numbers in a calcareous sandstone that forms a reeflike mass.

Sowerbyites delicatus is characterized by its small size, moderately auriculate cardinal extremities, gentle convexity of the pedicle valve, and gentle concavity in the brachial valve. The species is unlike *S. triseptatus* in its small size and relatively elongate form, and its cardinal extremities are not so strongly alate. It is smaller than all the other described species except *S. hami*. It is larger than the latter form but is not so convex in the pedicle valve nor so concave in the brachial valve.

SOWERBYITES GILDERSLEEVEI Cooper, new species

Plate 183, A, figures 1-16

Shell large, semicircular in outline with slightly obtuse to acutely angular cardinal extremities. Anterior margin very broadly rounded to nearly straight.

Lateral margins nearly straight to convex; anterolateral extremities strongly rounded. Surface marked by costellae of unequal size and narrow concentric wrinkles best defined between the hinge and the posterolateral region.

Pedicle valve moderately convex with the greatest convexity in the anterior half where the valve is gently geniculated. Umbonal region gently convex with a gentle concave slope to the cardinal extremities. A low fold extends from beak to front margin but is inconspicuous on geniculated portion. Midregion and anterior half of shell somewhat swollen. Cardinal extremities slightly deflected. Interarea long, apsacline; pseudodeltidium rudimentary.

Brachial valve gently concave in the posterior two-thirds but geniculated toward the brachial valve in the anterior third. Greatest concavity located just posterior to the geniculated part of the valve. Shallow median depression extending from the beak to geniculated part. Lateral regions of valve gently concave, becoming less concave toward the cardinal extremities. Umbo concave. Interarea short, hypercline.

Interior of pedicle valve with large callosities in front of the diductor-adjustor fields, well-developed pallial sinuses and well-defined genital impressions. Interior of brachial valve with high, thick median septum, large cardinal process, and thick but short lateral septa.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.0 | 11.5 | 22.7 | 25.0 | 2.8 |
| Paratype (pedicle valve 117401a)... | 13.0 | ? | 23.0 | 21.4 | ? |
| " (brachial valve 117401b)... | ? | 14.5 | 26.4 | 23.3 | ? |

Types.—Holotype: 117401z; figured paratypes: 117401b,d,e,h,k,m,n,p,q,v; unfigured paratypes: 117401a,c,f,g,i,j,l,o,r-u,w-y.

Horizon and locality.—Lincolnshire formation (8 feet below *Cybeloides* bed) in Virginia: Tumbling Run section, 1½ miles southwest of Strasburg, Strasburg (15') Quadrangle.

Discussion.—The specimens on which this species is based were etched from limestone and are quite coarsely silicified; consequently, some of the details are obscured. The pallial markings and septa of the interior, however, are well preserved, but the finer granulation of the internal surface and the finer costellae of the exterior are not retained in detail. On the best-preserved exterior of a brachial valve it is possible to count 6 fine costellae between the stronger ones which are about 1 mm. apart about one-third the distance from the anterolateral margin.

This species is closest to *Sowerbyites triseptatus* (Willard) but is larger and less convex in its mature stages. In old shells the front third to half of the pedicle valve is geniculated toward the brachial valve. The front quarter or third of the brachial valve is geniculated and thickened. Specimens of the pedicle valve of *S. gildersleevei* comparable in size to the type specimens of *S. triseptatus* are less convex than the latter but have more widely divergent and larger diductor-adjustor scars in the pedicle valve. Brachial valves of *S. gilder-*

sleevei are less strongly geniculated than the type brachial valve of Willard's species.

SOWERBYITES HAMI Cooper, new species

Plate 181, C, figures 19-33

Small for the genus, wider than long with the length about two-thirds the width at the hinge; cardinal extremities auriculate and forming an acute angle; sides gently rounded and sloping slightly toward the middle; anterior margin broadly rounded. Entire surface covered by very fine lamellae; larger costellae numbering about 2 to the millimeter at the anterior margin. Posterior margin with more or less well developed oblique wrinkles.

Pedicle valve evenly and gently convex in lateral profile and with the maximum convexity at about the middle; anterior profile broadly and gently convex. Umbo swollen, the swelling merging with that of the median region; flanks gently convex and sloping gently to the margins; anterior slope somewhat shorter and steeper than the lateral slopes. Interarea long and gently apsacline.

Brachial valve most deeply concave in the median region from the umbo nearly to the front margin; flanks gently concave; cardinal extremities somewhat flattened.

Interior of pedicle valve with little or no development of the callosities anterior to the diductor scars. Interior of brachial valve with low median septum and moderate development of the inner pair of septa; outer pair not well developed or absent.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 9.2 | 8.6 | 14.1 | 14.8 | 2.0 |
| Paratype (117400c) | 7.5 | 7.0 | 11.7 | 11.5 | 1.8 |
| “ (117400f) | 8.6 | 7.9 | 11.5 | 12.4+ | 1.9 |

Types.—Holotype: 117400a; figured paratypes: 117400b,d-f; unfigured paratypes: 117400c,g-j.

Horizon and locality.—Bromide formation (Pooleville member) in Oklahoma: From the shale beds immediately below the “Bromide dense” bed opposite the road leading to the abandoned village of Gilsonite; in the road cut on the east side of the section line road 1,300 feet south of the northwest corner of sec. 23, T. 1 S., R. 3 E., Murray County.

Discussion.—This species is characterized by its small size, moderately auriculate cardinal extremities, poorly developed outer lateral septa inside the brachial valve, and poorly developed callosities at the anterior ends of the diductor scars of the pedicle valve. Small size distinguishes this species from other described species of *Sowerbyites*. The modest projections on the cardinal extremities are unlike those of young *S. triseptatus* which are often mucronate. Young stages of *S. lamellosus*, as indicated by growth varices, seem to have been more transverse shells than the adult *S. hami*.

SOWERBYITES LAMELLOSUS Cooper, new species

Plate 180, C, figures 17-25; plate 181, B, figures 10-18; plate 184, G, figures 23-27

Shell of about usual size for the genus, length about two-thirds the width; hinge equal to or forming the greatest shell width; lateral margins nearly straight in the posterior half; anterolateral margins well rounded; anterior margin broadly rounded to truncated. Cardinal extremities varying from a right angle to acutely angular and subulate. Surface of exfoliated specimens costellate, with about 12 of the larger costellae occupying a space of 5 mm. at the anterolateral margins and 4 to 8 of the finest costellae occupying the spaces between the larger ones. When not exfoliated the shell is covered by extremely fine lamellae which are longest at the geniculated portion or anterior third of the pedicle valve. Lamellae of brachial valve not well developed.

Pedicle valve varying from gently convex to moderately convex in lateral profile with the greatest convexity at about the anterior two-thirds. Umbonal region slightly inflated with the slopes to the cardinal extremities gentle; anterolateral slopes steep; anterior slope steep. Interarea gently apsacline to orthocline. Pseudodeltidium short. When the lamellae of the exterior are present, the steepness and narrow convexity of the anterior third are emphasized.

Brachial valve gently concave in lateral profile with the greatest concavity located at the anterior third where the valve is somewhat sharply bent toward the brachial valve. Posterior two-thirds nearly flat but with a faint median sulcus originating at the beak and extending to the front margin in some specimens. Interarea short, hypercline. Cardinal extremities slightly deflected toward the pedicle valve. Exterior lamellae shorter and not so well developed as in the pedicle valve.

Interior of pedicle valve with outside margin of muscle area forming a right angle. Adductor impressions deeply sunk and located within the delthyrial chamber. Adjustor-diductor scars straight with outer margins slightly rounded, extending slightly anterior to the middle of the valve. Anterior callosities moderately thick.

Interior of brachial valve with low, rounded, thick median septum and 2 low but wide lateral septa, the inner lateral septum being the stronger of the two. Cardinal process moderately elevated; callus deposit about the cardinalia thick. Anterior slope steep; anterior end of median septum only slightly elevated.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.8 | 12.8 | 18.9 | 19.7+ | 4.9 |
| Paratype (117403a) | 13.3 | 12.0 | 21.3 | 22.8 | 2.8 |
| " (117405a) | 13.4 | 12.7 | 22.9 | 23.9+ | 3.0 |
| " (117405c) | 12.5 | 11.6 | 21.5 | 21.2 | 2.8 |
| " (117405d) | 13.1 | 12.8 | 21.6 | 22.7+ | 3.9 |

Types.—Holotype: 117406c; figured paratypes: 117402a-c,h, 117403a-c, 117405a-d; unfigured paratypes: 117402d-g, 117406a,b,d,e.

Horizon and locality.—Bromide formation (Mountain Lake member) in Okla-

homa: From bed 22 of Decker west of U. S. Highway 77, NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., north of Ardmore, Carter County; in reef limestone on the west side of the cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; sec. 20, T. 6 N., R. 15 W., north side of Wichita Mountains; 25 to 46 feet above the Bromide sand on Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County; West Spring Creek, east of Pooleville, Murray County; 150 feet below the top at the hairpin bend 0.1 mile below the Observation Point on the Scenic Drive, 1 mile east of U. S. Highway 77, center NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 29, T. 1 S., R. 2 E., Murray County.

Yellow shaly limestone just above a 25-foot bed of sandstone at base of the Eureka group in Nevada: In the saddle just north of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Doubtfully referred to this species are specimens from the Sevier formation in Tennessee: In a ravine on Tennessee Highway 73, 0.3 mile south-southeast of Walker Chapel, Kinzel Springs (T.V.A. 148-NE) Quadrangle; on Tennessee Highway 71 (Chapman Highway) 1.58 miles east-northeast of Cusick, Walden Creek (T.V.A. 156-SW) Quadrangle.

Discussion.—This species as here described is somewhat variable, but it is especially characterized by its transverse form, large size, and subrectangular outline. It is most like *S. triseptatus* from which it can be distinguished by the generally wider shells with more nearly rectangular cardinal extremities in the young. Inasmuch as *S. triseptatus* and *S. lamellosus* are both variable species, some specimens of each resemble the other markedly. Narrow individuals occur in both species, but the prevailing tendency is for the Oklahoma and Nevada specimens to be wider than the Tennessee and Virginia ones. *Sowerbyites lamellosus* is generally a smaller species than *S. gildersleevei* and does not attain the elaborate development of the interior seen in that Virginia species. The callosities at the front of the diductors are much stronger in the Virginia shells than in the Oklahoma ones.

Three lots of *Sowerbyites* from the Sevier formation of East Tennessee have been placed tentatively in this species. The specimens are not well preserved as they occur in a fine-grained sandstone and their exteriors are exfoliated. They do, however, have the somewhat transversely rectangular form of the Oklahoma and Nevada specimens and seem to occupy a somewhat post-Lincolnshire horizon.

SOWERBYITES SUBNASUTUS Cooper

Plate 182, A, figures 1-11

Species of about medium size for the genus, semielliptical in outline. Hinge forming the greatest shell width; cardinal extremities alate. Anterior margin somewhat narrowly rounded; lateral margins sloping obliquely anteromedially. Surface ornamented by costellae of unequal size; 9 of the larger costellae occupy a space of 5 mm. at the front of the holotype. Short concentric lamellae also present on the exterior.

Pedicle valve most strongly convex in the anterior third where the valve is strongly geniculated toward the brachial valve. Anterior slope moderately long and steep. Posterior two-thirds slightly convex. Umbo slightly swollen; beak small, protruding slightly posterior to the posterior margin. Median region slightly folded, but the fold is lost where the valve is geniculated. Lateral slopes moderately steep; interarea long for the genus, slightly curved, approximately orthocline. Pseudodeltidium small.

Brachial valve concave with the greatest concavity at the place of geniculation. Umbo concave; median sulcus shallow and poorly to well defined; areas bounding sulcus nearly flat or concave. Cardinal extremities sulcate. Interarea hypercline. Chilidium short.

Interior of pedicle valve with elongate diductors terminating in low callosities located at about the middle of the valve. Interior of brachial valve with prominent median septum highest at about the middle of the valve, lateral septa well developed, the inner 2 the stronger.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 12.1 | 10.6 | 15.0 | 17.2+ | 3.9 |
| Paratype (111797d) | 10.3 | 8.6 | 15.2 | 17.7+ | 3.2 |
| " (98187a) | 10.6 | 9.0 | 16.3 | 18.2 | 2.9 |
| " (117407a) | 10.5 | 9.2 | 13.8 | 16.1+ | 2.4 |

Types.—Holotype: 111797g; figured paratypes: 98187a-c, 111797a,d,f; unfigured paratypes: 111797b,c,e,h, 117407a-d.

Horizon and locality.—Lincolnshire formation in Virginia: In Marceum Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle.

Discussion.—This species is distinguished by its medium size, strong convexity of the pedicle valve and consequent deep concavity of the brachial valve, and the somewhat narrowly rounded anterior margin. It is smaller and deeper than *S. triseptatus*, *S. lamellosus*, and *S. gildersleevei*. Its size is similar to that of *S. delicatus*, but it is much more convex.

SOWERBYITES TRISEPTATUS (Willard)

Plate 169, B, figures 10-12; plate 180, A, figures 1-13; plate 182, B, figures 12-29;
plate 183, B, figures 17, 18; plate 209, B, figures 4-7

Plectambonites triseptatus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, pl. 2, figs. 7, 8, 1928.

Shell of about usual size for the genus, subsemicircular in outline with the width at the hinge nearly twice the length. Cardinal extremities acutely angular to auriculate. Lateral margins gently rounded, more or less sloping in an antero-median direction. Anterior margin moderately strongly rounded to only gently rounded. Surface marked by concentric undulations, scalloped on their edges. These undulations are formed by thin shell lamellae concentrated on the surface, and the scallops are produced by the undulation of the lamellae over costellae underneath. On the surface the costellae appear as depressed lines or radial

grooves in the lamellae. Where the lamellae have been stripped off, the ornamentation consists of fine and strong costellae. About 11 strong costellae occupy a space of 5 mm. at the front, and from 3 to 7 fine costellae occupy the space between the stronger ones. A few specimens with oblique wrinkles along the posterior margin.

Pedicle valve only slightly convex in the young but becoming moderately convex in lateral profile in old shells. Greatest convexity just anterior to the middle. Anterior slope somewhat steeper than the posterior one. Umbonal region a little inflated, beak not prominent but protruding very slightly posterior to the posterior margin. Posterolateral slopes gently concave and moderately steep. Interarea apsacline, slightly curved.

Brachial valve gently concave with the greatest concavity in the anterior third or half. Umbo sulcate, sulcus poorly defined to about middle of valve where it is lost; cardinal extremities sulcate; interarea short, hypercline; lateral areas gently concave.

Interior of pedicle valve with moderately strong callosities at the anterior ends of the diductor scars and located at or slightly anterior to the middle. Interior of brachial valve with strong median septum and well-developed lateral septa.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thickness |
|----------|----------------|--------|-----------------|----------|-------------|-----------|
| Hypotype | (117415g)..... | 11.2 | 10.0 | 17.4 | 21.0 | 2.2 |
| " | (111496a)..... | 12.6 | 11.1 | 17.1 | 17.8+ | 2.8 |
| " | (111496f)..... | 9.9 | 8.7 | 13.4 | 14.8+ | 2.3 |
| " | (117409a)..... | 10.5 | 9.6 | 17.0 | 18.9+ | 2.8 |
| " | (117409b)..... | 13.2 | 11.9 | 19.9 | 23.0 | ? |

Types.—Figured hypotypes: 111796a-c,e,f, 117409a-c,e, 117410a, 117411b, 117412b, 117413a,b, 117414a-c, 117415a,b,e,g,i,j, 123252a,b; measured hypotypes 111496a,f.

Horizon and locality.—Lincolnshire formation in Virginia: Near Goodwins Ferry on New River, Giles County; 1,000 feet north of road along Buffalo Creek, 2½ miles west of Murat, Rockbridge County; at the Dunkard Church, 6 miles north of Buchanan, Natural Bridge Special (15') Quadrangle; 1.8 miles S. 4° W. of Bethel Church, 5.9 miles due east of Harrisonburg, Harrisonburg (15') Quadrangle; ¼ mile northeast of the junction of Virginia County Highways 602 and 725, Augusta-Rockbridge County line.

Same formation in Tennessee: In Clinch Valley, 0.2 mile southwest of Shiloh Church, near the center of the northwest subquad., Pressmens Home (T.V.A. 171-NE) Quadrangle; ¾ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; 90 to 120 feet above the "Mosheim" limestone on U. S. Highway 25E, 1 mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; on U. S. Highway 25E north of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; ½ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; at Red Hill north of road 4½ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Lincolnshire formation (Hogskin member) in Tennessee: On Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn Station, Dutch Valley (T.V.A. 154-SE) Quadrangle; at the bend of the road, Red Hill, $4\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; on U. S. Highway 25E just south of the first bridge north of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; south side of the school at Chesney, Luttrell (T.V.A. 155-NW) Quadrangle; 1 mile southeast of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; in Maloneyville, John Sevier (T.V.A. 146-SE) Quadrangle; Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; Clinchport, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This is a very variable species as described herein. It is possible that more extensive collections will indicate further separations of geographically restricted forms, but the available collections will permit no such splitting. This species is characterized by its large size, generally alate cardinal extremities, at least in youthful forms, and the strong but not extravagant development of internal features. This species is smaller and usually more convex than *S. gildersleevei* and larger and less convex than *S. subnasutus*. The species is most like *S. lamellosus* but differs in having less transverse shells and generally more acute cardinal extremities. Some variants of each species resemble each other, but the majority of specimens of each species indicate the more transverse form and more rectangular outline of the western species.

Numerous specimens of *Sowerbyites* occur in the Hogskin shale and in thin, argillaceous limestones associated with the shale. These Hogskin forms are often more transverse than some of the specimens etched from Lincolnshire limestone. These, however, appear to be end members of the species. These wide forms are generally more acuminate on the cardinal extremities than *S. lamellosus*. They are also linked to the somewhat narrower limestone specimens by intermediate forms.

SOWERBYITES sp. 1

Of considerable interest in the stratigraphic and geographic distribution of this genus is its presence in the Quebec City formation. A single pedicle valve obtained from Dr. R. Bureau, Laval University, Quebec, indicates the species represented to be similar to *S. triseptatus* but not so transverse and somewhat rectangular on the cardinal extremities. In lateral profile the greatest convexity is at about the middle and the anterior slope is long and steep, its length about equal to that of the body of the shell. The angle of geniculation is about 100° .

Measurements in mm.—123300, length 14.4, surface length 17.0, midwidth 22.7, hinge width 23+, height 4.4.

Described specimen.—123300.

Horizon and locality.—Quebec City formation (Mountain Hill conglomerate) in Quebec, Canada: 400 to 500 feet south of Morin Building, Mountain Hill, Quebec City.

Subfamily ISOPHRAGMINAE Cooper, new subfamily

Small, resupinate, costellate shells having an exterior like *Palaeostrophomena* but with 2 long, parallel septa in the brachial valve.

ISOPHRAGMA Cooper, new genus

(Greek *isos*, equal; *phragma*, fence)

Shell small, usually wider than long with the hinge equal to or forming the greatest shell width. Resupinate; anterior commissure uniplicate; brachial valve sulcate in umbonal region, usually plicate in anterior half. Surface multicostellate; pseudopunctate.

Pedicle interior with small, stout teeth, having deep fossettes on their inner face; dental plates short and stout, usually obsolete because of filling of umbonal cavities by adventitious shell substance. Delthyrial cavity moderately deep; deltidium narrow and short. Sides of delthyrial cavity with marginal thickenings; interarea long, apsacline. Muscle field with elongate and narrow diductor impressions and small obscure adjustor impressions. Adductor track wide. Pallial trunks strongly marked, major trunks extending anteriorly from diductor impressions, one branch extending anteromedially, and another laterally. A second major trunk is given off laterally from near the ends of the dental plates and extends by a narrow curve anterolaterally. Several large callosities are located just within the anterior and lateral margins.

Brachial interior with short brachiophores and much thickened notothyrial platform. Sockets deep, brachiophores moderately large, flattened plates supported by lateral thickenings of the notothyrial platform. Cardinal process large, simple, situated on the posterior face of the notothyrial platform and in old shells produced forward as a ridge along the surface of the platform. Myophore carinate. Anterior to the notothyrial platform 2 subparallel ridges extend anteriorly nearly to the front margin. These ridges rise to a crest at a point slightly anterior to or nearly at the center of the valve. Ridges often greatly thickened and the space between them filled by excess shell substance. Adductor impressions located on each side of the median ridges; the posterior adductor scars the larger. Pallial impressions strong; 2 main trunks originating at the anteromedian extremities of the anterior pair of adductor impressions and extending anteriorly, bifurcating near the margin; a second pair of trunks extending anterolaterally from the line of contact of the anterior and posterior adductor scars; a third pair extending laterally from the posterior ends of the posterior adductor scars. Interarea hypercline.

Genotype.—*Isophragma ricevillense* Cooper, new species.

Discussion.—A casual study of these interesting shells suggests that the genus is a reversed *Sowerbyella* or *Leptelloidea*. Although the contour of the valves is reversed from that of the genera named, a sufficient number of internal structural differences between *Isophragma* and *Sowerbyella* and *Leptelloidea* are at once apparent and serve to distinguish the genera. Aside from its resupinate form, *Isophragma* is characterized by the strong subparallel lamellae forming the axis

of the brachial valve. Inside the pedicle valve the musculature is quite orthoid.

Isophragma differs from *Sowerbyella* in several important features. Inside the pedicle valve of *Sowerbyella* a short but prominent median septum located at the posterior of the valve divides the muscle field. Furthermore, the arrangement of the muscles is not the same as in *Isophragma*. Inside the brachial valve the notothyrial platform of *Isophragma* is not excavated under the cardinal process as it is in *Sowerbyella*, and the brachial processes are somewhat longer in the latter genus. Again in *Sowerbyella* the arrangement of the adductor scars of the brachial valve is not so orthoid as in *Isophragma*.

Leptelloidea and *Leptella* differ from the genus under discussion in the possession of an elevated visceral disk which is completely absent in *Isophragma*.

In the United States this genus has a moderately long stratigraphic range from the Arline formation of the Knoxville area into the Benbolt formation. Although this is a rather extensive stratigraphic range, no species is known between the intervals named. In Great Britain *Leptella? pseudoretroflexa* Reed from the Llandeilo (Balclatchie formation) belongs to this genus.

ISOPHRAGMA BISEPTATUM Cooper, new species

Plate 171, D, figures 20-29; plate 171, E, figures 30-32

Large for the genus, wider than long, with the greatest width at the hinge. Cardinal extremities varying with age from alate to approximately a right angle. Anterior margin broadly to narrowly rounded; lateral margins obliquely straight to slightly concave. Surface of an adult marked by about 75 narrowly rounded costellae having interspaces about the same width as the costellae. Growth lamellae strong, costellae often produced into short, blunt spines at the growth lamellae. Costellae crossed by minute elevated fila, at least 15 to 20 to the millimeter.

Pedicle valve nearly flat in lateral profile, umbo slightly swollen, the swelling extending forward as a low fold for one-fourth to one-third the length. Valve anterior to the fold flattened or slightly depressed to form a shallow sulcus, in some specimens the swelling continuing as a fold to the front margin. Tip of beak smooth and convex. Anterior and anterolateral portions of the adult very gently convex and with the cardinal extremities deflected slightly toward the brachial valve. Beak extended slightly beyond the posterior margin. Interarea broad and long, strongly apsacline. Deltidium long and narrow.

Brachial valve unevenly convex in lateral profile with the posterior third flattened or concave and the anterior two-thirds gently to moderately convex; gently convex in anterior profile. Umbo concave, the concavity a shallow pit just anterior to the posterior margin. Concavity extended anteriorly as a narrow and shallow sulcus for a short distance only or nearly to the front margin in young or middle-aged shells. Anteromedian region gently swollen; anterolateral areas gently convex with moderate slopes to the depressions defining the cardinal alae. Interarea shorter than the pedicle one, moderately long and hypercline in position.

Interior of pedicle valve with muscle area about as long as wide, with square

anterior margin, deeply impressed and narrow diductor impressions, and wide, shallow adductor field. Delthyrial cavity filled with callus; anterior portion of muscle area thickened and elevated. Visceral region much thickened and with many oblique subperipheral ridges.

Interior of brachial valve with thickened median septum rising to a sharp crest near the middle of the valve and composed of 2 nearly parallel septa cemented together by shell material. Adductor impressions short and narrow, deeply impressed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 10.5 | 9.4 | 13.7 | 14.7 | 3.4 |
| Paratype (110905b) | 9.6 | ? | 12.2 | 13.0 | 1.8 |
| " (110905c) | 8.4 | 7.4 | 11.8 | 14.1 | 3.0 |
| " (110905d) | ? | 7.4 | 10.7 | 13.0 | ? |

Types.—Holotype: 110905a; figured paratypes: 110905b-d, 117373a, 117374a,b; unfigured paratypes: 110904, 117373b.

Horizon and locality.—Benbolt formation in Virginia: At 40 feet above the base, $\frac{1}{4}$ mile southeast of Green Valley Church, 3 miles southwest of Lebanon, Brumley (T.V.A. 205-SE) Quadrangle; $\frac{1}{2}$ mile northeast of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Botetourt formation in Virginia: On the south side of U. S. Highway 60, 1 mile northwest of Lexington, Lexington (15') Quadrangle; at the junction of Virginia Highways 731 and 724, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Arline formation in Virginia: Quarry at Marion, Marion (T.V.A. 218-SE) Quadrangle.

Discussion.—This species differs from other known Appalachian species by its relatively greater length, length/width ratio varying from 0.70 to 0.85. The brachial interior is somewhat less thickened and the callus swelling about the median septa much less developed than in *I. ricevillense* which most nearly approaches this species in size. This Benbolt species will not be confused with the Arline *I. extensum* which is a quite slender form usually of small size. The *I. subabbreviatum* again is smaller and possesses a median structure much more highly elevated in the direction of the pedicle valve than that of *I. biseptatum*.

ISOPHRAGMA EXTENSUM Cooper, new species

Plate 170, C, figure 17; plate 170, D, figures 18-29; plate 171, A, figures 1-14;
plate 171, C, figures 16-19; plate 184, F, figures 19-22

Shell of about medium size for the genus, nearly twice as wide as long at the hinge and with the hinge forming the widest part. Cardinal extremitites acute to alate. Front margin broadly rounded to truncate. Surface marked by costellae of unequal size; 2 to 4 of the smaller costellae occupy the space between the

larger ones; about 16 costellae occupy a space of 5 mm. at the front of a valve about 6 mm. long.

Pedicle valve flat to slightly concave in lateral profile; beak slightly projecting posterior to the posterior margin; umbo narrow, slightly swollen and produced forward as a narrow, low fold which may or may not disappear at about the middle of the valve. Anteromedian portion anteriorly depressed to form a shallow, wide sulcus. Area bounding sulcus slightly folded; lateral areas nearly flat to concave. Interarea moderately long, apsacline.

Brachial valve with sulcate umbo; sulcus extending nearly to middle of valve; anteromedian half of valve undulated into a broad fold; lateral areas slightly convex and with steepening slopes toward the margins. Area in front of cardinal extremities sulcate. Interarea moderately long but shorter than the interarea of the pedicle valve, hypercline.

Interior of pedicle valve well thickened; delthyrial cavity small, choked with excess shell at the apex; ridges between pallial impressions thick; surface covered by small granules.

Interior of brachial valve with paired septa extending nearly to the front margin but with the crests of the septa at about the middle of the valve; adductor field small, surrounded posterolaterally by narrow ridges. Radial thickenings between pallial impressions moderately strong.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 7.8 | 6.6 | 12.8 | 14.8 | 2.2 |
| Paratype (117376b) | 7.0 | 5.9 | 10.0 | 12.3 | 2.8 |
| " (110909a) | 7.4 | 6.7 | 11.2 | 14.1+ | 2.4 |

Types.—Holotype: 117376a; figured paratypes: 110908a,b-d,g,h, 110909a, 110911a,d, 110912, 117375, 117376c-f,k,l; unfigured paratypes: 110908e,f, 110909b, 110911b,c, 117376b,g-j,m,n.

Horizon and locality.—Arline formation in Tennessee: 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of center of Friendsville; glade $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 1,500 feet south of Burnett Creek, Shooks Gap (T.V.A. 137-NE) Quadrangle.

Arline formation in Virginia: Near entrance to Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Little Oak formation in Alabama: At junction Bailey Gap road and Cahaba Valley road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Discussion.—This species is characterized by its great width along the hinge as compared to its length. Furthermore, the cardinal extremities are acutely angular even in the adult form, thus differing from *I. biseptatum*. From *I. ricevillense* this species differs in its more acute cardinal extremities, greater width, and less even character to the costellae.

ISOPHRAGMA PONDEROSUM Cooper, new species

Plate 210, H, figures 25-32

Large for the genus, subrectangular in outline; sides rounded, somewhat oblique; anterior margin broadly rounded; cardinal extremities acute; anterior commissure rectimarginate. Costellae strong, numbering 13 to 14 in 5 mm. at the front margin.

Pedicle valve nearly flat in lateral and anterior profile; beak low; umbo narrowly rounded and extended to about the middle as a low fold; anterior half slightly depressed to form a barely perceptible sulcus; sides bounding fold slightly concave on each side of the fold but becoming flat on the lateral extremities. Interarea moderately long, strongly apsacline; deltidium narrowly rounded.

Brachial valve faintly convex in lateral and anterior profiles; umbo sulcate, the sulcus extending to about the middle; anterior third gently swollen to form a barely perceptible fold. Flanks bounding sulcus gently convex. Interior with septa united into a broad ridge rising to a crest at its free extremity slightly anterior to the valve middle.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 10.7 | 9.9 | 13.6 ? | 14.6+ | 2.9 |
| Paratype (123261) | 9.4 | ? | 14.8 | 17.3 | ? |
| “ (123262a) | 11.6 | ? | 15.8 | 16.4+ | ? |

Types.—Holotype: 123259a; figured paratypes: 123261, 123262a; unfigured paratypes: 123259b, 123262b.

Horizon and locality.—Yellow-weathering limestone on 25-foot sandstone at base of Eureka group in Nevada: 2 and 3 miles north of Martin Ranch, Roberts Mountains (1°) Quadrangle.

Discussion.—This is the largest species of the genus known. Like most of the other species the young stages are very transverse, but in this western form the cardinal angles tend to become less obtuse as adulthood and old age are reached. This species is suggestive of *I. biseptatum* but differs, besides its size, in being more elongate, having a flatter brachial valve and a more apsacline interarea. The Nevada species is much less transverse than *I. ricevillense*, is not so strongly sulcate, has a less pronounced brachial fold and a more apsacline interarea.

ISOPHRAGMA RICEVILLENSE Cooper, new species

Plate 170, A, figures 1-15

Shell large for the genus, wider than long and with the hinge forming the widest part of the shell; cardinal extremities varying from a right angle to acute; anterior margin broadly rounded. Valves subequal in depth, the brachial valve having a slightly greater depth than the pedicle one. Surface marked by subequal narrowly rounded costellae, about 14 in the space of 5 mm. at the front of a valve 7 mm. long. Two generations of costellae intercalated between the primary ones.

Pedicle valve flat or slightly concave in lateral profile; umbo slightly swollen;

folded portion of umbonal region short; front half of valve gently concave; lateral regions nearly flat; extremities deflected slightly toward the brachial valve. Interarea moderately long, apsacline.

Brachial valve forming a gentle sigmoidal curve in lateral profile; umbonal region narrowly sulcate, sulcus shallow, noticeably extending to the middle of the valve and more indistinctly extending nearly to the front margin; anterior half gently swollen and folded in anterior profile to correspond to concave portion of the pedicle valve. Lateral areas flattened to gently concave; interarea hypercline, short.

Interior of pedicle valve only slightly thickened in the young but with large subperipheral callosities and deeply intrrenched pallial marks in old shells. Interior of brachial valve with septa short and elevated to a crest at about the middle. Adductor impressions deep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.4 | 7.2 | 12.0 | 13.3 | 2.4 |
| Paratype (pedicle valve 110923a)... | 7.6 | ? | 10.7 | 14.0 | ? |
| " (" " 110923b)... | 8.6 | ? | 12.7 | 13.9 | ? |
| " (" " 110923f)... | 5.0 | ? | 8.8 | 9.6 | ? |
| " (brachial valve 110923c)... | 8.4 | ? | 10.2 | 11.5 | ? |
| " (" " 110923d)... | 7.2 | ? | 11.9 | 12.5 | ? |
| " (" " 110923e)... | 6.7 | ? | 12.0 | 14.7 | ? |
| " (" " 110920)... | 7.8 | 7.0 | 11.7 | 13.0 | 2.1 |

Types.—Holotype: 110918a; figured paratypes: 110923a-d,g; unfigured paratypes: 110918b, 110920, 110923e,f.

Horizon and locality.—Base of Athens formation in Tennessee: Just east of intersection, 2½ miles southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle; 660 feet S. 40° E. of the railroad intersection 1 mile north of Athens, Athens (T.V.A. 125-SE) Quadrangle.

Discussion.—*Isophragma ricevillense* attains a fairly large size for the genus and differs from *I. biseptatum* in size and thickness of shell, a lesser development of the median ridge, and more clearly defined pallial impressions. It differs from *I. extensum* in a lesser development of cardinal extremities and somewhat coarser and more even development of the costellae.

ISOPHRAGMA SUBABBREVIATUM Cooper, new species

Plate 169, A, figures 1-9

Shell slightly wider than long, subrectangular in outline; valves thick. Cardinal extremities in the young acutely angular but forming nearly a right angle in the adult. Front margin subtruncate; anterolateral margins broadly rounded; lateral margins oblique. Surface multicostellate, 7 costellae occupying a space of 2 mm. at the front of the holotype. Costellae nearly equal in size.

Pedicle valve with a moderately strong but narrow fold extending from the beak nearly to the front margin. Front third of valve depressed into a broad,

shallow sulcus occupied by about 16 costellae. Lateral areas bounding sulcus slightly convex, depressed below the median fold. Interarea long, apsacline.

Brachial valve with a shallow, narrow sulcus originating at the beak and extending distinctly for slightly more than half the length where it becomes shallower and passes into a broad gentle fold. Lateral areas convex except near the posterior margin where they are slightly sulcate. Anterolateral slopes moderately steep. Interarea moderately long, hypercline.

Interiors of both valves greatly thickened and all structures enlarged. Delthyrial cavity partially filled by excess shell; subperipheral callosities often ponderous. Inside the brachial valve the median septa are welded into a single spoonlike process highest at the center. Internal surfaces strongly granulose.

Measurements.—Holotype, length 6.3, midwidth 8.4, hinge width 8.2, thickness 2.8.

Types.—Holotype: 110916a; figured paratype: 110916b; unfigured paratypes: 110912, 110916c.

Horizon and locality.—Arline formation in Tennessee: In glade $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—*Isophragma subabbreviatum* in outline and profile differs from other known species. It is more quadrate than any known form, and the median ridge is strongly and abruptly turned toward the pedicle valve.

ISOPHRAGMA SULCATUM Cooper, new species

Plate 170, B, figure 16

Shell small, planoconvex in lateral and anterior profiles, wider than long with the hinge forming the greatest width; cardinal extremities alate; anterior margin truncated; anterolateral extremities narrowly rounded; lateral margins nearly straight, oblique. Surface multicostellate, costellae of unequal size, about 3 to 4 in a millimeter at the front margin.

Pedicle valve with low narrow median fold and slightly convex flanks; interarea long, apsacline. Brachial valve deeply sulcate at the umbo with sulcus extending to the front margin, narrow and moderately deep throughout its length. Sides of shell nearly flat. Interarea procline. Brachial interior with septa nearly reaching the front margin.

Measurements in mm.—Holotype, length 5.9, brachial length 4.8, width 18.7, hinge width 11.6, thickness 1.4.

Type.—Holotype: 110917.

Horizon and locality.—"Lenoir" formation (lowest beds with *Christiania* just above the Lenoir [with *Maclurites*] and below the Pratt Ferry formation) in Alabama: 0.15 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species differs from others herein described by its flat and deeply sulcate brachial valve. The single known specimen shows also the 2 median septa as shallow, slightly divergent plates extending almost to the front margin. In this respect the species differs from other known forms in which the median septa extend scarcely beyond the middle of the valve.

ISOPHRAGMA sp. 1

Plate 213, B, figure 21

A small brachial valve, nearly plane in profile and with moderately strong costellae, was taken in the residues from the Pratt Ferry limestone. The interior shows the subparallel plates which in this specimen are somewhat thinner than in other species. The discovery is interesting because *Isophragma* occurs below the Pratt Ferry limestone in the upper part of the so-called Lenoir and also in the contemporary Little Oak formation. This helps to emphasize the close relationships of these various formations.

Figured specimen.—123286.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Family TAPHRODONTIDAE Cooper, new family

Plectambonitacea having an exterior like *Sowerbyella* but the brachial valve having orthoid cardinalia, thick notothyrial platform, high, bladelike cardinal process, and long slender brachiophores. Median ridge formed of 2 subparallel plates.

TAPHRODONTA Cooper, new genus

(Greek *taphros*, ditch; *odont*, tooth)

Shell small, about $\frac{1}{2}$ inch in width; suggesting *Sowerbyites* or *Sowerbyella* in appearance; pedicle valve gently convex; brachial valve concave; anterior commissure rectimarginate; surface multicostellate; pseudopunctate.

Pedicle valve with narrowly convex, fairly strongly elevated pseudodeltidium; delthyrial cavity moderately deep; dental plates short and stout; teeth flat, oblique, double, the two processes separated by a deep, slitlike fossette; muscle field somewhat heart-shaped, the diductor scars wide and oval, the adjustor scars not differentiated; adductor scars small, located between diductors near center of muscle field. Median area just anterior to muscle field thickened; area anterior to this median thickening forming a sulcus that extends to the anterior margin; lateral areas bounding sulcus thickened and roughened, the thickening not reaching the margins.

Brachial interior with thickened notothyrial platform filling or nearly filling the notothyrium; cardinal process a slender median ridge on the notothyrial platform; sockets deep; brachiophores long, bladelike, pointed distally but thickened by an articulating boss opposite the point where the brachiophore joins the notothyrial platform; median ridge anterior to notothyrial platform composed of 2 thick, united septa rising to a crest near the anterior margin; inner margin anterior to median septa thickened and extending as a thick, pustulose band corresponding to the marginal troughlike band of the pedicle valve.

Genotype.—*Taphrodonta parallela* Cooper, new species.

Discussion.—The exterior features of this genus form an almost exact convergence toward other genera in other geological periods. The most distinctive

feature of *Taphrodonta* is thus its interior characters. Inside the pedicle valve the dental plates and articulatory apparatus are like those of *Palaeostrophomena* and other Plectambonitacea. The muscle field is rather generalized and without septa, at least in this species. Perhaps the most distinctive feature of the interior of the pedicle valve is the thickening of the flanks of the shell on each side of the median sulcus and posterior to the margin. This makes a raised or thickened visceral area but a thin marginal zone. The latter evidently fits closely to the thickened marginal zone of the brachial valve. The anterior shallow marginal area is strongly pustulose.

The most striking feature of the brachial valve interior is the long median ridge consisting of 2, or what appear to be 2, septa welded together to make a broad ridge with an elevated margin on each side. This ridge is joined to the notothyrial platform which carries a thin blade for a cardinal process. The brachiophores are moderately long, their proximal ends buried in the tissue of the notothyrial platform. Where the brachiophore protrudes from this tissue it is thickened on the outside, the boss thus produced undoubtedly sharing in the articulation of the valves. The distal end of the brachiophore is a short, sharp, and thin crus like that seen in some orthids such as *Hesperorthis*.

Of especial interest in this genus is the marginal region of the brachial valve which is considerably thickened and forms a steep slope that fits into the thinned marginal area of the pedicle valve. Both areas, the thinned one of the pedicle valve and the thickened area of the brachial valve, are strongly pustulose. In opening, only a thin passage would result between the valves, the pustules forming an effective type of strainer. This role for the pustules also may be seen in the Productacea where it is developed to perfection.

The ensemble of characters in this genus are most suggestive of *Isophragma* which also possesses a median ridge very much like that of *Taphrodonta*. Despite the similarities, strong differences may be detected. In the first place the exterior of the two genera is unlike. *Isophragma* has a reversed convexity to the brachial valve. It is concave in the young but becomes convex anteriorly. In other words the convexity is the reverse of that of *Taphrodonta*.

Inside the valves other differences may be seen between *Taphrodonta* and *Isophragma*. The muscle field of the pedicle valve of the latter genus is wide, extends to about the middle, and has elongate diductor scars, whereas this feature of *Taphrodonta* is short and narrow. The teeth of *Isophragma* seem to be more simply constructed. Inside the brachial valve the median ridge shows its dual origin more strongly in *Isophragma* than in *Taphrodonta*. Furthermore, the brachiophores of *Isophragma* are short, flat blades and the cardinal process, although simple, is inclined to be bulbous.

TAPHRODONTA PARALLELA Cooper, new species

Plate 165, A, figures 1-22

Small, semielliptical in outline with the hinge forming the widest part; cardinal extremities acutely pointed; sides moderately oblique, slightly rounded; anterior

margin broadly rounded. Costellae narrowly rounded, distant, numbering about 3 to the millimeter at the anterior margin.

Pedicle valve unevenly convex in lateral profile, the posterior third to half somewhat flattened but the anterior half moderately convex; anterior profile broadly convex with the median ridge forming a somewhat obtusely angulated crest. Umbo narrowly convex, the convexity produced anteriorly to about the middle as a low and narrow fold which disappears in the somewhat swollen anterior; flanks bounding fold slightly convex, gently depressed below the fold; anterior third of median region and flanks gently bent and somewhat swollen to form a moderately long and steep anterior slope. Interarea moderately long, strongly apsacline.

Brachial valve gently concave in lateral profile and with the maximum depression just anterior to the middle and located at the sloping anterior face of the inner median ridge. Umbo sulcate, the sulcus produced anteriorly nearly to the anterior margin as a widening but shallow depression. Flanks bounding sulcus nearly flat. Cardinal extremities flattened. Interarea short, anacline.

Measurements in mm.—Holotype, length 8.6, brachial length 8.0, midwidth 12.1, hinge width 13.7+, thickness 1.9, height 2.4.

Types.—Holotype: 117562e; figured paratypes: 117562b,f-i; unfigured paratypes: 117562a,c,d.

Horizon and locality.—Upper Pogonip group in Nevada: In Ikes Canyon 1 mile above the entrance, Toquima Range, Roberts Mountains (1°) Quadrangle.

Discussion.—No other species of this genus is known to which this species may be compared. The exterior form and profiles of the genus are like a number of other genera. This genus on its exterior could be mistaken for *Sowerbyites* but as far as known is not externally lamellose and has a flatter brachial valve than the members of that genus. It might be confused with *Palaeostrophomena*, but the members of that genus usually have convex brachial valves.

Family SYNDIELASMATIDAE Cooper, new family

Plectambonitacea having an exterior like that of *Sowerbyella* but cardinal process simple and not fused to the brachiophores.

SYNDELASMA Cooper, new genus

(Greek *syn*, together; *di*, two; *elasma*, plate)

Shell attaining $\frac{1}{2}$ inch in width, thin, compressed, concavo-convex, semielliptical in outline; sowerbyelloid in profiles and general appearance; hinge forming the widest part of the shell; cardinal extremities auriculate; ornamentation distantly costellate. Posterior margin with oblique wrinkles. Pseudopunctate.

Pedicle interior without dental plates; muscle area lightly impressed. Interarea short; pseudodeltidium much reduced or absent. Other details not known.

Brachial interior with sockets small, moderately deep, bounded by slender brachiophores produced into thin, sharp points; cardinal process a short bulb when viewed from the side of the pedicle valve; posterior of bulb marked by 3

septa; cardinal process covered by a narrow, convex chilidium; bulbous cardinal process buttressed by a short shaft lying at the posterior termination of 2 thin, elevated septa which rise to their highest point near the anterior margin; anterior ends of septa not thickened; inner margin not thickened; entire inner surface marked by coarse granules especially well developed in the anterior parts of the shell.

Genotype.—*Syndielasma biseptatum* Cooper, new species.

Discussion.—This genus in its external form and profiles is most like *Sowerbyella*. It also resembles *Sowerbyella* in its interior characters but has a number of primitive features which separate it from that genus. The known specimens of *Syndielasma* are not so concave as usual in *Sowerbyella*, and the shell is much more compressed than is usual in that genus. The pseudodeltidium of *Syndielasma* is much reduced and in this respect has surpassed *Sowerbyella*. The chilidium of *Syndielasma* is well developed and forms a narrow arch over the cardinal process. Thus the posterior characters of *Syndielasma*, if well preserved, should distinguish it from *Sowerbyella*.

The 2 long, high septa of the brachial interior of *Syndielasma* are obviously like those of *Sowerbyella*. The later members of the latter genus, however, usually have the front ends of the septa thickened and grown together by shell substance to produce a steep anterior slope off the front ends of septa. The real distinction between *Syndielasma* and *Sowerbyella* is in the cardinalia, particularly the cardinal process. In *Sowerbyella* the cardinal process is joined to the chilidial plates and brachiophores to form a tentlike structure that overhangs the notothyrial region. In *Syndielasma*, on the other hand, the cardinal process is a thick boss with a short shaft occupying the notothyrial cavity. The brachiophores of *Syndielasma* in their slender and widely divergent character are not unlike those of *Sowerbyella*. *Syndielasma* thus combines features that are definitely like those of *Sowerbyella* with others that remind one strongly of *Palaeostrophomena* and its allies.

It is doubtful if *Syndielasma* is one of the progenitors of *Sowerbyella* because it occurs with *Sowerbyella bellarugosa*. This species occurs at the same horizon and locality and has the tentlike cardinalia of true *Sowerbyella*. It is best to regard *Syndielasma* as an early off-shoot from the line that produced *Sowerbyella*.

SYNDELASMA BISEPTATUM Cooper, new species

Plate 185, C, figures 14-29

Shell attaining about $\frac{1}{2}$ inch in width, wider than long, semielliptical in outline; hinge forming the greatest shell width; cardinal extremities alate; sides oblique; anterior margin broadly rounded; shell thin, valves compressed to form an unusually narrow body chamber; costellae narrowly rounded, distant, about 11 in 5 mm. at the front margin. A few oblique wrinkles along the posterior margins.

Pedicle valve gently convex in lateral profile; anterior profile broadly and slightly convex, the maximum convexity at the middle; beak small, protruding slightly posterior to the posterior margin; umbo narrowly and slightly swollen

to produce a low but short fold that may die out near the middle but in some specimens continues more or less prominently to the front margin; flanks slightly convex, long and low.

Brachial valve nearly flat to gently concave; greatest concavity just anterior to the middle; umbo sulcate, the sulcus continuing and widening anteriorly to form a prominent but shallow depression that terminates at the anterior margin. Flanks bounding sulcus flat to gently concave; cardinal extremities flattened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 8.8 | 8.5 | 13.9 | 15.6 ? | 1.0 | 1.8 |
| Paratype (117565c) ... | 9.6 | 9.0 | 13.7 | ? | 1.4 | 1.9 |

Types.—Holotype: 117565g; figured paratypes: 117565a-e,h,i; unfigured paratypes: 117563a-c, 117565f,j,k.

Horizon and locality.—Pogonip group (upper 30 feet) in Nevada: About 1 mile above the entrance to Ikes Canyon, Toquima Range, Roberts Mountains (1°) Quadrangle.

Discussion.—No other species of this genus is now known to which *Syndielasma biseptatum* may be compared. This species occurs with *Taphrodonta parallela* which it resembles in superficial characters. *Taphrodonta*, however, is a smaller, differently proportioned, and stouter shell than that of *Syndielasma* so that the two should not be confused.

Family LEPTELLINIDAE Ulrich and Cooper, 1936

Concavo-convex, costellate Plectambonitacea with low and expanded cardinal process plate and more or less well developed visceral disk.

Subfamily HESPEROMENINAE Cooper, new subfamily

Leptellinidae having rudimentary visceral disk.

HESPEROMENA Cooper, new genus

(Greek *hespera*, west; *mene*, crescent)

Shell with outline and profiles of *Leptellina*; strongly geniculated near the middle; surface marked by alternating fine and coarse costellae. Pseudopunctate.

Pedicle valve without dental plates and with deep delthyrial cavity; muscle field large; diductor scars long and slender. Other details not known. Pseudodeltidium long, moderately convex.

Brachial valve with short, stout brachiophores; median septum low; cardinal process forming a small suboval shelf overhanging the notothyrial region; cardinal process with median septal ridge and 2 lateral lobes separated by a narrow groove. Visceral area marked by a thickened line. Entire surface strongly pustulose.

Genotype.—*Hesperomena leptellinoidea* Cooper, new species.

Discussion.—The interior of this genus is most like that of *Leptellina* but differs in not having a strong visceral disk marked by a shelf overhanging the geniculated portion of the brachial valve interior. It also differs from *Leptellina* in the development of the cardinal process. This structure in *Leptellina* consists of 2 lateral plates attached to the inner edges of the brachioophores which are fused to a ridgelike cardinal process; the latter may or may not overhang the notothyrial region to some extent. In *Hesperomena*, on the other hand, the cardinal process is constructed like that of *Leptellina*, but the fused structure is oval in outline and overhangs the notothyrial area to a considerable extent.

The structure of the pedicle valve is also different from that of *Leptellina*. The latter genus has well-marked dental plates and a short, usually wide, muscle area. In *Hesperomena*, on the other hand, dental plates are wanting and the muscle area is large, with long diductor scars completely unlike those of *Leptellina*. *Hesperomena* in its lack of an overhanging visceral disk might be supposed to be primitive, but the cardinal process appears to be more advanced than in *Leptellina* itself.

HESPEROMENA LEPTELLINOIDEA Cooper, new species

Plate 185, A, figures 1-10

Shell moderately large, wider than long; hinge not equal to the greatest shell width which is near the middle; sides moderately rounded; anterior margin strongly rounded; surface marked by distant rounded costellae.

Pedicle valve unevenly convex in lateral profile, most convex just anterior to the middle where the valve is abruptly geniculate toward the pedicle valve; anterior profile broadly and gently convex; posterior half gently convex; umbo narrowly swollen, the swelling forming a short and inconspicuous fold. Anterior half gently swollen and bent toward the pedicle valve to form a long trail with steep and long anterior slope. Interarea moderately long, apsacline.

Brachial valve most concave just anterior to the middle; posterior half gently concave; anterior half deflected toward the brachial valve and forming steep slopes from the cardinal extremities to the anterior: umbo sulcate, the sulcation forming a shallow and narrow depression which is lost on the brachial trail. Interarea short, hypercline.

Measurements in mm.—Holotype, length 14.7, brachial length 12.6, midwidth 23.2, hinge width 19.2, thickness 3.4, height 5.9.

Type.—Holotype: 117560.

Horizon and locality.—Pogonip group (upper 30 feet) in Nevada: About 1 mile above the entrance to Ikes Canyon, Toquima Range, Roberts Mountains (1°) Quadrangle.

Discussion.—No other species of this genus is known to which this one may be compared. The measurements of midwidth and hinge width given above are based on the half width of the shell.

Subfamily LEPTELLININAE Ulrich and Cooper, 1936

Plectambonitacea having the general appearance of *Leptelloidea* and with an elevated visceral disk in the brachial valve. When present, the cardinal process is a simple ridge with a lateral ridge on each side.

Genus PETRORIA Wilson, 1926

Plate 22I, E, figures 29-36

Petroria WILSON, Geol. Surv. Canada, Bull. 44, pp. 27-29, pl. 5, figs. 15-18, 1926.

Since its proposal this genus has not been very well known, and some question attends its proper age designation. The type specimens were taken from the Beaverfoot limestone and are associated with an equivocal assemblage. The gastropod *Palliseria* has proved to be identical with *Mitrospira* which forms a prominent zone in the high Pogonip of western United States. *Petroria* does not have the structure of the more advanced leptelloids to which it is related but is more suggestive of the Canadian genus *Leptella*. In accord with this view is the presence of *Orthis marshalli* Wilson and *Plectorthis ? sinuatis* Wilson which are Canadian types. Although the writer has not seen specimens of either of them, the first species suggests *Orthambonites* and the second reminds one strongly of *Orthidiella*. It seems very probable, from the above evidence, that Canadian and Richmond fossils have been brought together by structural complications.

Through the kindness of Dr. W. A. Bell of the Canadian Geological Survey the writer was permitted to etch apart the valves of one of the cotypes of *Petroria rugosa*. The specimen selected for this delicate operation was G. S. C. 6754a. Part of the pedicle valve of this specimen had been broken off, but the brachial valve was nearly intact. The etching process was carried out successfully, and the two valves were easily separated.

The pedicle valve has a moderately long interarea slightly overhanging the delthyrial cavity which is moderately deep. Dental plates are not visible. If they existed in the young *Petroria*, they have been obliterated by shell deposit in the umbonal and delthyrial chambers before the individual reached the size of the specimen under examination. The muscle area is somewhat triangular and is not deeply impressed. Each of the vascula media consists of 2 narrow channels separated by a broad fold, thus forming a double track extending from the anterolateral angle of the muscle area obliquely for half the shell length. The shell is somewhat thickened at the anterior extremity of the pallial trunk.

In the brachial valve the chilidial plates are prominent and almost close the notothyrium. The interarea is moderately long. No cardinal process is present, a feature suggesting *Leptella* and early origin. The sockets are shallow and formed by the sloping face of the short brachial processes. The notothyrial cavity is made obsolete by swelling of shell substance between the brachiophores. The median ridge extends to the extremity of the visceral disk and is continued from there to the shell margin. The visceral disk is low, not extended strongly over the anterior trail. The muscle field is oval and somewhat thickened.

Petroria is very much like *Leptella*, but a few distinctions between the genera can be readily seen. The known specimens of *Leptella* do not show the prominent, wavy lamellae of the exterior of *Petroria*. Inside the pedicle valve *Leptella* is provided with a callosity at the anterior end of the muscle area which is lacking in the Beaverfoot genus. The median septum of *Petroria* is more prominent and is extended anterior to the anterior margin of the visceral disk unlike that of *Petroria*. Neither genus is provided with a cardinal process. This feature characterizes many of the early brachiopods and suggests an early Ordovician rather than late Ordovician age for *Petroria*. Although the two genera are basically similar, the differences mentioned are sufficient to distinguish them.

Genus LEPTELLINA Ulrich and Cooper, 1936

Leptellina ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 626, 1936; Geol. Soc. Amer. Special Pap. 13, p. 190, 1938.

LEPTELLINA ABBREVIATA Cooper, new species

Plate 191, C, figures 23-31

Shell of about average size for the genus, slightly wider than long; greatest width at the hinge line. Cardinal extremities rounded, nearly a right angle. Lateral margins nearly straight, anterior margin narrowly rounded. Surface multicostellate, marked by about 19 thin, highly elevated, strong costellae of which about 5 reach the beak; spaces between larger costellae occupied by very fine costellae about 8 in 1 mm. on the brachial valve where they are best preserved. In addition to the radial ornamentation most of valves covered by fine, closely spaced concentric lamellae, usually stripped away from some part of the shell.

Pedicle valve strongly convex in lateral profile and with the greatest convexity at about the middle; posterior third somewhat flattened. Anterior profile still more convex than the other; the greatest convexity is at the middle, but the sides slope steeply to the margins. Umbonal region somewhat flattened; midregion swollen, and with concave posterolateral slopes to the cardinal extremities. All slopes including the posterior slope steep. Interarea long, slightly curved, anacline.

Brachial valve moderately concave with the greatest concavity developed in the median region. Umbo slightly concave; posterolateral areas flattened; lateral and anterior portions moderately steeply folded in the direction of the brachial valve. Interarea nearly as long as the pedicle one; hypercline. Chilidium small.

Interior: Pedicle muscle field pentagonal with large, widely divergent adjustor impressions. Diductor impressions elongate tear-shaped, subparallel; adductor impressions fairly large and located at the base of the callus filling the deep delthyrial cavity. Between the anterior ends of the diductors occurs a crater with steep, coarsely granulose anterior face and moderately deep cavity. Anterior and lateral portions of valve strongly granulose. Brachial valve with short but wide visceral disk occupying less than the posterior half.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|----------------|--------|
| Holotype | 9.8 | 8.3 | 11.9 | 12.4 | 3.8 | 13.5 | 5.0 |
| Paratype (117433g) .. | 9.7 | ? | 12.1 | 13.0 | ? | 12.0 | 3.4 |

Types.—Holotype: 117433a; figured paratype: 117433b; unfigured paratypes: 117433c-h.

Horizon and locality.—Oranda formation in Virginia: In the railroad cut $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species is characterized by its medium size, strong, distant costellae, strong convexity, and the large size and considerable width of the muscle field of the pedicle valve. This species is marked somewhat like *L. pulchra*, but that species is a much larger one. *Leptellina abbreviata* resembles smaller specimens of *L. tennesseensis* but differs markedly in the ornamentation particularly on the anterior portion of the valve. *Leptellina delicatula* is approximately the same size as the Oranda species but is a squarer form with a much longer pedicle interarea than the Virginia species. *Leptellina incompta* and *L. abbreviata* are approximately the same age, but the Virginia species is much more convex than the Nevada one although the pedicle interiors are similar.

LEPTELLINA BELLA Cooper, new species

Plate 186, A, figures 1-8; plate 190, A, figures 1-4

Shell small for the genus, wider than long, strongly concavo-convex; hinge forming widest part; cardinal extremities nearly rectangular, slightly auriculate. Lateral margins nearly straight; anterior margin very broadly rounded. Surface multicostellate, costellae of 3 sizes. In young stages about 7 of the larger costellae extending from the beak to the margin, but in adults addition of costellae of intermediate size in the front half increases the number of larger costellae to about 20 on each side of the median costella. The strongest of the costellae is the median one which is wider and more elevated than the others. The costellae of the 2 larger sizes are set in a field of very fine costellae about 15 in 1 mm. This figure includes 1 large costella. In addition to the radial ornamentation the surface of the posterior part of the valves particularly is marked by minute concentric wrinkles.

Pedicle valve moderately to strongly convex in lateral profile with the greatest convexity in the anterior half while the posterior half is only very gently convex; anterior profile highly arched. Beak protruding slightly posterior to the posterior margin; umbo swollen and elevated slightly. Lateral and anterior slopes very steep. Median region somewhat more swollen than the surrounding areas to form an ill-defined fold. Interarea moderately long, apsacline.

Brachial valve deeply concave with the greatest concavity in the median portion; region near cardinal extremities less concave. Umbonal region only gently concave. Interarea hypercline. Chilidium small.

Interior: Muscle area of the pedicle valve deeply impressed, very small, having a length equal to about one-sixth that of the valve. Vascula media or main

pallial trunks slender, divergent, not deeply impressed and extending to about the middle. Brachioophores short, slender; median ridge slender, well elevated; visceral disk wide, occupying the posterior two-thirds to three-fifths of the valve. Muscle marks not deeply impressed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 7.4 | 6.4 | 8.9 | 8.9 | 2.5 |
| Paratype (117435a)..... | 6.0 | ? | 7.2 | 8.9 | ? |
| " (117435b)..... | 6.3 | ? | 8.3 | 9.6 | ? |
| " (brachial valve 117435d).... | ? | 5.3 | 8.2 | 8.5 | ? |

Types.—Holotype: 117434c; figured paratypes: 117434b, 117435b,c,f; unfigured paratypes: 117434a, 117435a,d,e,g-i.

Horizon and locality.—Whitesburg formation in Tennessee: 1½ miles west of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Chatham Hill formation in Virginia: Grayson Farm, 4 miles southwest of Bland, Bland County.

Discussion.—This is a small and beautifully marked species characterized by the fairly close crowding of the major costellae on the anterior slope and the prominence of the median costella. This species is unlike any other described in its ornamentation. It is suggestive of *L. tennesseensis* in ornamentation, but that species attains twice the size of *L. bella*.

LEPTELLINA DELICATULA (Butts)

Plate 188, C, figures 13, 14; plate 191, D, figures 32-39

Plectambonites delicatula BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 116, pl. 26, figs. 20, 21, 1926.

Plectambonites cf. *P. pisum* BUTTS, idem, p. 116, pl. 26, figs. 18, 19, 36, 37, 1926.

Shell of about medium size for the genus, subquadrate in adult outline, a little wider than long; cardinal extremities acute to obtuse depending on age and preservation. Lateral margins rounded, oblique to nearly straight. Front margin narrowly rounded. Surface marked by costellae of 3 sizes. In young specimens 5 large costellae stand out over a field of very fine costellae. In adults many costellae of intermediate size are intercalated on the anterior slope and number about 40. These are separated by the finest costellae about 7 in a millimeter measured at the front of the brachial valve of an adult.

Pedicle valve strongly convex in lateral profile with the greatest convexity located at about the middle; anterior profile a strongly convex bow equal in height to about half the width of the shell. Umbo and beak inconspicuous; middle and anterior portions strongly swollen; lateral slopes descending steeply to the lateral and cardinal extremities. Interarea long, orthocline, slightly curved. Pseudodeltidium short, strongly arched.

Brachial valve deeply concave with the greatest concavity at about the center; lateral and anterior portions strongly elevated to form a deep cup. Valve shallow at cardinal extremities which are somewhat flattened. Lateral margins sloping

rapidly to cardinal extremities. Umbonal region only slightly concave; region on each side of umbo and along posterior margin flattened. Interarea short, about half the length of the pedicle interarea; hypercline.

Interior: Pedicle valve having dental plates strong with deep umbonal cavities, sloping inward; teeth small; delthyrial chamber deep. Muscle field thickened, short as usual in the genus. Ridge in front of muscle field extending to about middle. Brachial valve with long, slender brachial processes extending strongly anterolaterally. Other visible features as usual in the genus.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 6.9 | 5.8 | 9.0 | 8.5 | 9.7 | 1.9 | 3.3 |
| Hypotype (71499a)... | 7.8 | 6.4 | 9.5 | 8.7 | 8.9 | 2.1 | 3.7 |
| " (117436d) .. | 10.2 | 7.5 | 13.5 | 10.8 | 11.0+ | 2.9 | 5.0 |
| " (117436a) .. | 8.4 | 6.9 | 11.5 | 8.8 | 10.7 | 2.4 | 4.6 |

Types.—Holotype: 71500; figured hypotypes: 117436a,d,e; unfigured hypotypes: 71499a, 117436b,c.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile north-northeast of Pelham, Bessemer Iron District (15') Quadrangle; west side U. S. Highway 31, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 20 S., R. 3 W., $\frac{1}{3}$ mile N. 10° E. of Pelham Station, 2 miles north of Pelham, Bessemer Iron District (15') Quadrangle; intersection of Bailey Gap road with main road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Discussion.—This species is somewhat variable and has an interesting growth development. The young are transverse and have acute cardinal extremities. The adult form has an unusually long interarea on the pedicle valve, and the outline becomes strongly rectangular with the length slightly less than the width. The long interarea on the pedicle valve, the deep brachial valve and rectangular form distinguish *L. delicatula* from all the other species herein described. This species never attains the large size of *L. tennesseensis* which is its closest relative in time and appearance.

LEPTELLINA INCOMPTA Cooper, new species

Plate 191, B, figures 9-22

Shell of about medium size for the genus, wider than long with the hinge equal to or forming the greatest width; sides moderately oblique, gently rounded; anterior broadly rounded; costellae not visible on perfect specimens because of the crowded, thin lamellae which give the shell a rough or untrimmed appearance; costellae of 2 sizes, the larger ones about 1 mm. apart at the front margin of an adult, remainder of shell covered by a mat of fine costellae.

Pedicle valve evenly and moderately convex in lateral profile; anterior profile moderately domed, with the median region somewhat narrowly convex and with long, steep lateral slopes. Beak small and narrowly protruding slightly posterior to the posterior margin; umbo moderately convex; median region moderately swollen; posterior slope shorter and somewhat steeper than the anterior slope.

Interarea long, gently apsacline. Interior with deep delthyrial cavity having thickened walls; dental plates obscured by adventitious shell. Muscle field large, with elongated diductor scars occupying the posterior third; vascula media short, separated by a narrow granular area.

Brachial valve moderately deep, the depth increasing with age; maximum concavity just anterior to the middle; umbo and surrounding area gently concave; cardinal extremities flattened. Interarea short, hypercline. Interior with low visceral disk having a highly elevated median septum.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 10.4 | 8.8 | 13.5 | 14.2 | 14.4 ? | 2.8 | 4.8 |
| Paratype (117438a)... | 9.1 | 7.7 | 11.5 | 12.2 ? | 14.0 ? | 2.2 | 3.8 |
| " (117438b)... | 8.0 | 6.9 | 10.5 | 10.0 | 11.1 | 2.3 | 3.4 |

Types.—Holotype: 117438c; figured paratypes: 117438a,b,d,e.

Horizon and locality.—Dark shale below Eureka quartzite in Nevada: On the north-facing nose of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—Specimens of this species have a ragged appearance because of partial peeling of the fine lamellae. Transverse form, low convexity and a large pedicle muscle area characterize this species. *Leptellina abbreviata* is thought to be of about the same age, but *L. incompta* is a much less convex form. *Leptellina sublamellosa* is also characterized by prominent development of the lamellae, but the species is somewhat smaller, more transverse, and proportionately more convex.

LEPTELLINA OCCIDENTALIS Ulrich and Cooper

Plate 189, C, figures 30-37

Leptellina occidentalis ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 191, pl. 39B, figs. 3, 7, 1938.

Additional material of this species collected after the appearance of Special Paper 13 has yielded specimens quite suitable for illustration of many of the characters mentioned in the original description. Not seen in the original material are the fine lamellae which cover most of the surface, like those of other well-preserved specimens of *Leptellina* from higher formations. This species is readily distinguished from all other known species of the genus by its small size, gently convex to nearly flat brachial valve, and the low and short visceral disk.

Types.—Holotype: 92869a; paratypes: 92868a, 92869b-d, 92870a,b; figured hypotypes: 108133a-e, 117440a-c.

Horizon and locality.—Common in the topmost beds of the Pogonip group in Nevada: In Ikes Canyon, on the east side of the Toquima Range, Roberts Mountains (1°) Quadrangle.

LEPTELLINA PLATYS Cooper, new species

Plate 186, D, figures 13, 14

Shell of about medium size for the genus, of low convexity, wider than long and with the hinge about equal to the maximum width. Sides slightly oblique,

gently rounded; anterior margin broadly rounded. Costellae of several sizes, about 2 of the larger ones in a millimeter at the front margin.

Pedicle valve with lateral profile gently convex and with the maximum convexity slightly anterior to the middle; anterior profile broadly and moderately convex and with long, gentle lateral slopes; umbo gently convex; median region gently swollen; interarea long, apsacline.

Brachial valve gently concave and with the maximum concavity at about the middle; umbo concave; posterior slope descending moderately toward the middle; cardinal extremities somewhat flatly concave; interarea short, hypercline.

Measurements in mm.—Holotype, length 10.0, brachial length 8.8, surface length 11.5, midwidth 14.2, hinge width 15.6, thickness 2.3, height 3.4.

Type.—Holotype: 117439.

Horizon and locality.—Benbolt formation in Virginia: $\frac{1}{4}$ mile east of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is characterized by its low convexity and is therefore directly comparable to only two other species: *L. occidentals* and *L. primaria*. From the former *L. platys* differs in size and ornamentation; from the latter it differs in being somewhat more convex and having stronger ornamentation.

LEPTELLINA PRIMARIA Cooper, new species

Plate 187, A, figures 1-7

Shell large for the genus, concavo-convex but not strongly convex; cardinal extremities rectangular to acute; lateral margins sloping inward; anterior margin broadly rounded. Surface marked by narrowly rounded, distant costellae, about 5 in the space of 1 mm. at the front of a valve about 7 mm. long. In addition to costellae most of the anterior three-quarters is covered by fine concentric lamellae.

Brachial valve moderately concave and agreeing well with the convexity of the pedicle valve; umbo concave, extended forward as a narrow but moderately deep sulcus for at least half the length of the valve, not well defined in the anterior portion. Posterolateral areas bounding posterior part of sulcus flattened; lateral areas gently concave. Interarea short, hypercline.

Interior: Interior of pedicle valve unknown. Brachial interior with a low visceral disk occupying slightly more than the posterior half; median ridge low and wide. Cardinalia with short, thick, divergent brachial processes. Cardinal process simple, intimately grown to the chilidial plates, the anchylosed structures forming a narrow plate. Musculature not preserved.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 10.7 | 9.4 | 12.0 | 14.8 | 16.6 ? | 2.0 | 3.5 |
| Paratype (117441b)... | 6.9 | ? | 7.0 | 8.9 | 10.9 | ? | ? |

Types.—Holotype: 117441d; figured paratypes: 117441a-c.

Horizon and locality.—Crown Point formation in New York: Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Same horizon in Vermont: Just north of neck of Providence Island, Lake Champlain, Plattsburg (15') Quadrangle.

Discussion.—This species is a fairly early member of the genus as it occurs in the Crown Point formation of the Chazy group. It is flatly convex, is lamellose like most other species and has fairly fine ornamentation. It is also characterized by a large visceral area which does not strongly overhang the geniculated trail. This species differs from all others herein described, except *L. platys* and *L. occidentalis*, in its low convexity. It is a larger and deeper shell than *L. occidentalis* but is somewhat less convex and larger than *L. platys* and is differently ornamented.

LEPTELLINA PULCHRA Cooper, new species

Plate 189, A, figures 1-23; plate 195, C, figures 9-16; plate 219, G, figure 14

Shell large for the genus, strongly concavo-convex, wider than long. Cardinal extremities obtuse, auriculate. Lateral margins well rounded; anterior margin broadly rounded. Surface marked by 8 to 10 narrow, elevated threadlike costellae that stand out over a field of very fine costellae, about 5 in 1 mm. The fine costellae are of very even grade. In addition to the costellae, 2 specimens show evidence of fine concentric lamellae like those of *Sowerbyites*. In some specimens a few oblique wrinkles are present along the posterior margin on each side of the beak.

Pedicle valve with posterior third somewhat flattened but strongly convex in the anterior two-thirds in lateral profile; anterior profile a narrowly rounded arch. Beak small, protruding slightly beyond the posterior margin. Umbonal region slightly swollen; swelling continued forward in the median part of the valve to the front margin to form a fold. Lateral slopes slightly convex, steep. Anterior slope steep. Interarea slightly apsacline.

Brachial valve deeply concave with the greatest concavity just anterior to the middle; umbo concave, the concavity continued anteriorly as a poorly defined sulcus; flanks gently concave and regions parallel to posterior margin also concave. Cardinal extremities concave.

Interior: Muscle area of pedicle valve wide and short, equal in length to about one-quarter the length of the valve; dental plates short and stout; adjustor-diductor patches set off from the adductor field by low ridges in old shells; pallial sinuses not strongly impressed. Brachial valve with well-developed, large visceral area, the front margins of which are produced forward and overhang the geniculated front slope; median ridge slender, high, not extending to the chamber under the cardinal process. Brachial processes slender and flat. Cardinal process a slender ridge bounded by 2 triangular depressions, the whole grown together with the chilidial plates to form a single plate, which in this species, is undercut and overhangs an umbonal chamber somewhat like the cardinalia of *Sowerbyella*. Area of muscle attachment thickened and marked by oblique ridges.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 12.8 | 11.2 | 14.5 | 17.4 | 18.8 ? | 2.2 | 5.5 |
| Paratype (117444m) . | 13.5 | ? | 18.0 | 17.0 | 18.9 | ? | 7.3 |
| " (117443) ... | 12.7 | 12.2 | 17.5 | 17.9 | 16.5 | 2.7 | 5.9 |
| " (117444e) .. | 14.7 | ? | 19.0 | 17.2 | 18.0 ? | ? | 8.0 |

Types.—Holotype: 117444d; figured paratypes: 117442a-e, 117443, 117444a-c, e-h, 123284; unfigured paratypes: 117444i-m.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Edinburg formation (lower Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles due east of Harrisonburg, Harrisonburg (15') Quadrangle.

Botetourt formation in Virginia: 1 mile northwest of Lexington, Lexington (15') Quadrangle.

Benbolt formation in Virginia: $\frac{1}{2}$ mile southeast of Richpatch, Eagle Rock (15') Quadrangle.

Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is one of the largest and most beautiful of this genus. It is characterized exteriorly by having strong and distant costellae in a mat of fine costellae. The distant nature of the larger costellae is maintained on the geniculated trail as well as on the posterior part. In this respect it differs from *L. tennesseensis*, its nearest relative, in which the trail is marked by fairly crowded major costellae.

LEPTELLINA SUBCARINATA Cooper, new species

Plate 190, E, figures 32-39

Shell wider than long with rectangular or obtuse cardinal extremities; lateral margins gently rounded; anterior margin broadly rounded to somewhat nasute. Surface multicostellate, costellae of 3 sizes, many of the ones of intermediate size intercalated at the place of geniculation and occupying the front slope which is thus marked by many of the larger costellae. About 60 of the strong and intermediate costellae may be counted at the front margin of an average-size shell.

Pedicle valve moderately convex with the greatest convexity in the midregion. Anterior profile only moderately convex with moderately steep sides sloping away from a low, rounded median elevation. Fold low, narrow, extending to the front margin. Interarea moderately long with a narrow delthyrium and narrowly arched pseudodeltidium.

Brachial valve having a moderate concavity, deepest in the posterior part of the median region. Concavity extending forward nearly to the front margin in correspondence with the fold of the pedicle valve. Lateral regions bounding

the sulcus gently convex to flattened depending on the age. Interarea short, hypercline.

Interior: Muscle area of pedicle valve small, deeply impressed, equal to about one-fourth the width and one-fifth the length. Dental plates short, umbonal cavities well filled by callus in the adult. Vascula media of the pallial system short, not deeply impressed. Ridge anterior to muscle field fairly high, thin and well anterior of the muscle field. Brachial valve with only moderately large visceral area which extends anteriorly to about the middle of the valve, and is produced forward as an overhanging ledge for a short distance. Median ridge broad and low. Muscle marks not well impressed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 8.0 | ? | 9.9 | 13.8 | ? |
| Paratype (pedicle valve 117446f) ... | 10.3 | ? | 13.4 | 14.1 | ? |
| " (brachial valve 117446b) .. | ? | 7.8 | 12.3 | 12.8 | ? |

Types.—Holotype: 117446a; figured paratypes: 117446b,c,f-h; unfigured paratypes: 117446d,e,i-k.

Horizon and locality.—Base of Athens formation in Tennessee: 2½ miles south-southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle; 2 miles south of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle; 600 feet S. 40° E. of the railroad crossing 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-SE) Quadrangle; 0.2 mile southeast of Britton Church, 2½ miles northeast of Calhoun, Calhoun (T.V.A. 125-SW) Quadrangle.

Discussion.—This species is known only from the base of the Athens shale in the belt running through Athens, Tenn. The species has moderate convexity, a somewhat keeled pedicle valve, small muscle field in the pedicle valve, and the visceral disk not strongly overhanging the trail. The species is nearest *L. tennesseensis* but never attains the large size of that species nor its great convexity.

LEPTELLINA SUBLAMELLOSA Cooper, new species

Plate 188, B, figure 12; plate 188, D, figures 15-24; plate 190, B, figures 5-8;
plate 190, C, figures 9-25

Small, wider than long and with the hinge forming the widest part; cardinal extremities acute; sides oblique, gently rounded; anterior margin broadly to narrowly rounded; surface finely costellate, costellae of unequal size; part or most of surface covered by closely spaced wavy lamellae.

Pedicle valve with strongly convex lateral profile, the maximum convexity located at or near the middle; anterior and lateral slopes nearly equal in length and nearly equal in steepness; anterior profile ranging from moderately to strongly convex in the median region and with long, steep lateral slopes. Beak small; umbo and median regions swollen. Interarea moderately long, orthocline. Interior with short but deeply impressed muscle scars; vascula media inconspicuous.

Brachial valve fairly strongly concave particularly in the median region and

just anterior to it; umbo concave; area just anterior to posterior margin forming a more or less deep groove extending to the cardinal extremities. Interarea moderately long, hypercline. Interior with strong, erect cardinal process, strong median ridge, and elevated visceral disk with margins overhanging geniculated area; pallial marks impressed on geniculated area.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 8.1 | 6.6 | 10.5 | 9.9 | 10.8 | 2.6 | 3.9 |
| Paratype (117447a)..... | 7.8 | 6.4 | 10.5 | 9.6 | 10.7 | 2.7 | 3.9 |
| " (117447b)..... | 8.2 | 6.9 | 11.0 | 10.0 | 10.6 | 2.5 | 3.7 |

Types.—Holotype: 117447g; figured paratypes: 117447b,e,f,h, 117449a,c,d,f,g, 117450a, 117451a; unfigured paratypes: 117447a,c,d,i, 117448, 117449b,e, 117450b, 117451b,c.

Horizon and locality.—Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle; Grayson Farm, 4 miles southwest of Bland, Bland County.

Benbolt formation (base) in Virginia: West side of hill east of Cedar Point School, Hilton (T.V.A. 197-NE) Quadrangle; 0.2 mile south of middle fork of Moccasin Creek, 1½ miles due south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Edinburg formation (*Cyrtonotella* zone) in Virginia: Ravine on south side railroad tracks, ¼ mile east of Strasburg Junction, Strasburg (15') Quadrangle; (?) 1½ miles north of Double Toll Gate, Winchester (15') Quadrangle.

Discussion.—This species is characterized by its ragged exterior produced by patches of lamellae of considerable size adhering to the shell. The species is of moderate size and fairly transverse. It is not so large nor so convex as *L. abbreviata* but is more convex than *L. incompta* which it resembles in its ragged exterior. *Leptellina sublamellosa* is like some of the younger forms of *L. delicatula* but does not attain the rectangular outline nor does it develop the long interarea as on the pedicle valve of the Alabama species.

LEPTELLINA TENNESSEENSIS Ulrich and Cooper

Plate 187, C, figures 9-13; plate 187, D, figures 14-30; plate 188, A, figures 1-11;
plate 189, B, figures 24-29; plate 190, D, figures 26-31

Leptellina tennesseensis ULRICH and COOPER, Journ. Paleont., vol. 10, No. 7, p. 626, 1936;
Geol. Soc. Amer. Special Pap. 13, p. 192, pl. 39A, figs. 1, 2, 4, 5, 1938.

Plectambonites delicatulus RAYMOND (not Butts), Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 297, pl. 3, fig. 11, 1928.

Shell large, variable, varying from wider than long to having the length and width about equal. Cardinal extremities acute and generally auriculate. Lateral margins nearly straight or oblique and generally rounded in old specimens. Front margin broadly to narrowly rounded, occasionally somewhat nasute. Surface multicostellate; young valves marked by 5 narrow but strong primary costellae that extend to the beak. As the shell grows, costellae of a size intermediate

between these and the fine costellae covering most of the surface are intercalated and become most numerous on the anterior and anterolateral slopes. Eleven or twelve of these costellae occupy a space of 5 mm. at the front margin. As many as 4 of the finest costellae occupy the space between the intermediate costellae.

Pedicle valve moderately convex in lateral profile with the greatest convexity at about the middle in young specimens but in the posterior half in old specimens. Front profile variable depending on the age; most strongly convex in the older individuals. Beak inconspicuous; umbo small, slightly swollen, extended forward as an ill-defined fold on the flattish posterior portion, but generally not continued far forward, although some specimens show evidence of an indistinct fold at the front margin. Posterolateral slopes gently concave. Anterolateral slopes generally steep in shells of all ages; front slope steep to moderately steep depending on age, the older shells having a longer and more gentle anterior slope. Interarea only slightly curved, apsacline to orthocline. Pseudodeltidium moderately long, narrowly arched.

Brachial valve following the curvature of the pedicle valve fairly closely, most deeply concave at the middle or slightly posterior to the middle. Umbo gently concave with the concavity produced anteriorly to about the middle. Posterolateral regions flattened. Cardinal extremities sulcate. Interarea short, hypercline.

Interior of pedicle valve with small teeth, dental plates strongly convergent, thick; umbonal cavities well filled by callus. Delthyrial cavity moderately deep; muscle marks well impressed on a thickened delthyrial floor. Diductor-adjustor scars small, often separated by a low ridge at the posterior of which is located the small oval adductor field. Vascula media often much thickened, short, having the first bifurcation at about the middle of the valve.

Brachial valve with a visceral disk occupying about two-thirds the width and more than half the length. Median ridge strongly elevated at the front, lost in the callus under the cardinalia. Cardinal process and chilidial plates forming a flat piece supported anteriorly by a thickening of callus. Brachial processes long, flat plates. Adductor scars not discernible.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 10.5 | 8.2 | 13.5 | 10.4 | 12.0 | 3.2 | 4.4 |
| Hypotype (108135s) .. | 10.4 | 8.3 | 12.5 | 12.3 | 10.6 ? | 3.6 | 5.6 |
| " (108135h) .. | 11.4 | 9.0 | 16.0 | 12.5 | ? | 3.2 | 5.8 |
| " (108139) ... | 11.8 | 10.3 | 15.5 | 14.8 | 14.6 | 2.6 | 5.4 |

Types.—Holotype: 92871; figured hypotypes: 108135d,e,g,h,m,o,p,s-u, 117452, 117453a,b, 117454a,b, 117455a,b, 117456a, measured hypotype: 108139.

Horizon and locality.—Arline formation in Tennessee: On both sides of an old road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 3 and 6 miles southeast of Knoxville; McMullens, Meadow (T.V.A. 139-NW) Quadrangle; 1,500 feet south of the mouth of Burnett Creek, Shooks Gap (T.V.A. 147-NE) Quadrangle; 6 to 10 miles southeast of Loudon, Loudon

(30') Quadrangle; 2 miles south of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle; quarry $\frac{1}{2}$ mile northeast of St. Clair, Bulls Gap (T.V.A. 171-SE) Quadrangle; 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 10 feet below Holston=Red Knobs formation, 1 mile east-northeast of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle.

Arline formation in Virginia: Quarry at Marion, Marion (T.V.A. 218-SE) Quadrangle.

Fetzer tongue in Tennessee: On the south side of the road 200 yards southwest of Blockhouse, Blockhouse (T.V.A. 148-NW) Quadrangle.

Tellico formation in Tennessee: On the Chapman Highway (Tennessee Highway 71) 1.3 miles east-northeast of Cusick, Walden Creek (T.V.A. 156-SW) Quadrangle.

Little Oak formation in Alabama: Lock 3, cut on Seaboard Airline RR. 6 miles east-northeast of Ragland, St. Clair County.

Botetourt formation in Virginia: On Virginia Highway 114, 2.3 miles west of the Montgomery-Roanoke County line, 12 miles northeast of Blacksburg.

Discussion.—This species as here described is a somewhat variable form consisting of individuals having the length and width nearly equal while others are definitely somewhat transverse. The exterior is characterized by strong convexity and a strongly geniculated trail marked by somewhat crowded strong costellae between which occur finer ones. The anterior is often somewhat nasute when viewed from the side showing the brachial valve. Young forms are transverse. Inside the pedicle valve the muscle area is small for such a large shell and contrasts strongly with *L. abbreviata* which is smaller but with a huge muscle area.

Leptellina tennesseensis is a large species and is thus comparable to *L. pulchra*; it differs from that species in its less transverse outline and in the possession of crowded larger costellae on the geniculated trail.

LEPTELLINA TRANSVERSA Cooper, new species

Plate 191, A, figures 1-8

Shell of about usual size for the genus, unusually transversely subelliptical in outline. Hinge forming widest part. Lateral and anterior margins forming a single broad curve. Surface costellate, 3 to 5 of the larger costellae in a space of 2 mm. at the anterior margin.

Pedicle valve strongly convex in lateral profile with the maximum curvature near the middle. Anterior profile a broad arch slightly elevated medially. Umbo narrowly convex; beak small, protruding very slightly posterior to the posterior margin which is nearly straight. Umbonal ridge continued anteriorly as a low and narrow fold for about three-fourths the valve length but less distinctly in the anterior quarter. Flanks broad, slightly concave or nearly flat and with long, gentle slopes. Anterior slopes very steep. Interarea moderately long, apsacline.

Brachial valve deeply concave in lateral profile, the concavity closely follow-

ing that of the pedicle valve. Umbo sulcate, the sulcus being continued anterior to the front margin as a narrow, shallow depression. Flanks bounding sulcus broadly and gently concave transversely but narrowly and deeply concave longitudinally. Interarea short, hypercline; cardinal process and chilidial plates small, fused into a single plate.

Interior of pedicle valve with widely flaring dental plates. Interior of brachial valve with median septum reaching the point of maximum curvature and moderately elevated anteriorly but very low posteriorly. Edge of visceral area low and inconspicuous.

Measurements in mm.—Holotype, length 9.2, brachial length 7.6, surface length 12.5, midwidth 20.9+, hinge width ?, thickness 2.8, height 4.5.

Types.—Holotype: 117457a; figured paratype: 117457c; unfigured paratypes: 117457b,d.

Horizon and locality.—Arline formation (near top) in Virginia: Near entrance to Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species has some of the features of *L. tennesseensis*, to which it is probably related, but differs therefrom by its unusually transverse outline. It differs from all other species of *Leptellina* herein described by the same character.

LEPTELLINA sp. 1

Plate 187, B, figure 8

A new species represented by a single brachial interior is the largest *Leptellina* yet found. Its length is 16.3 mm., midwidth 26.1 mm., hinge width 27.4 mm. plus. The brachioophores are short; the cardinal process fused with chilidial plates is large and overhangs the interior; the median septum originates $2\frac{1}{2}$ mm. anterior to the cardinal process and is narrow and elevated at the front. It terminates at the anterior end of the visceral disk which is 11 mm. long and moderately overhangs the anterior geniculated part of the valve. Muscle scars cannot be differentiated.

Figured specimen.—117459.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Virginia: In the ravine opposite the switch just east of Strasburg Junction, Strasburg (15') Quadrangle.

BILOBIA Cooper, new genus

(Latin *bi*, two; *lobus*, lobe)

Shells small, concavo-convex, with the pedicle valve tumid; cardinal extremities auriculate; anterior commissure sulcate; surface multicostellate; a few strong costellae standing out in a field of very fine costellae.

Pedicle valve with deeply impressed large muscle field; diductor scars elongate, divergent; adductor field oval in outline, deeply impressed, separating the posterior ends of the diductors. Teeth thick; dental plates stout; umbonal cavities filled by callus; dental plates extended as stout ridges around outside margin

of muscle field. Vascula media short and thick, bifurcating into a larger inner branch and a small, shorter outer branch. Interarea curved, longer than the one on the brachial valve, hypercline. Pseudodeltidium short.

Brachial interior with strongly bilobed visceral disk, lobes triangular to rounded and the seat of attachment of the adductor muscles. Lobes with elevated rims on inside; rims extending nearly to cardinal process. Lobes separated by a high, thin median septum extending to about the middle. Brachial processes short and small; cardinal process with short, stout shaft bearing 3 ridges on the myophore face, a median elevated ridge and lateral lower ridges.

Genotype.—*Bilobia hemisphaerica* Cooper, new species.

Discussion.—*Bilobia* can be recognized by its nearly hemispherical brachial valve and the bilobed character of the visceral disk. The genus is most like *Leptellina* in all its characters but differs in its greater sphericity, generally larger pedicle muscle field, and in the bilobed character of the visceral disk. The latter is brought about by lack of development of a prominent median septum.

In the European faunas *Bilobia* occurs in the Kuckers formation of Estonia where it is represented by *B. musca* (Öpik). It occurs in the Girvan fauna of Scotland where it is known as *Bilobia etheridgei* (Davidson). In the Appalachians this genus has been taken from the lower part of the Edinburg (*Cyrtotellina* zone) Shippensburg, and Oranda formations. It is also known in the Rysedorf conglomerate. It extends from the Oranda into the base of the Martinsburg shale in Virginia where it occurs with elements of the Salona fauna.

BILOBIA HEMISPHAERICA Cooper, new species

Plate 192, C, figures 16-20; plate 193, C, figures 10-15; plate 193, D, figures 16-36;
plate 194, F, figures 31-36

Plectambonites pisum BASSLER (not Ruedemann), Cambrian and Ordovician: Maryland Geol. Surv., p. 253, 1919.

Shell small, almost hemispherical in lateral profile; wider than long with the greatest width at the hinge; cardinal extremities auriculate. Lateral and anterior margins irregular; front margin varying from broadly rounded to nasute. Posterior swollen part of pedicle valve marked by 3 strong costellae that stand out over all the others. At the front margin about 17 strong costellae occur in a matrix of fine lines, 8 or 9 of the latter in a space of 1 mm. The costellae of the brachial valve seem to have fewer of the large costellae, but this may be because of faulty preservation. Many of the specimens in the anterior parts of both valves are marked by concentric lamellae like those of the associated *Bimuria lamellosa*.

Pedicle valve nearly hemispherical in lateral profile and narrowly convex in anterior profile. Umbo and median part of valve swollen; all slopes steep but more particularly the lateral ones which may be as steep or steeper than the anterior slope. Posterolateral area leading to the cardinal extremities narrowly rounded. Interarea short, curved, acutely hypercline in position. Pseudodeltidium short in the middle part, extended laterally as an elevated rim on the sides of the delthyrium.

Brachial valve deeply concave with the greatest concavity at about the middle. Posterolateral areas concave; umbo concave; lateral and anterior portions strongly folded toward the brachial valve to form a deep cup of the valve. Chidium large; interarea short and hypercline.

Interior: Pedicle interior with deeply sunk muscle field, diductor scars long, straight, and divergent; pallial and genital marks strongly impressed. Brachial valve with moderately elevated adductor lobes, moderately strong median septum.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 9.0 | 6.1 | 15.0 | 10.5 | 11.7 | 2.9 | 5.8 |
| Paratype (111099a).... | 9.3 | 7.0 | 15.0 | 9.0 | 10.0 | 3.6 | 6.0 |
| " (117461a).... | 7.7 | 6.6 | 11.0 | 9.2 | 9.7 | 3.3 | 4.1 |

Types.—Holotype: 111099b; figured paratypes: 111087a-c, 111099a,c-f, 117460a,b, 117461a,b, 117462; unfigured paratypes: 111087d, 111099g-k, 117461c.

Horizon and locality.—Oranda formation in Virginia: $\frac{1}{2}$ mile west of Strasburg; just west of junction of Virginia Highways 617=910, and 777, about 0.2 mile north of Green Mount Church, Broadway (15') Quadrangle; Bowman Farm, 0.3 mile east of U. S. Highway 11, 1 mile southwest of Woodstock, Edinburg (15') Quadrangle; on Virginia Highway 55, 0.4 mile west of U. S. Highway 11, north edge of Strasburg, Strasburg (15') Quadrangle; on U. S. Highway 11, $\frac{1}{2}$ mile south-southwest of Tumbling Run, southwest of Strasburg, Strasburg (15') Quadrangle; 200 yards southeast on Virginia Highway 616, 3.5 miles southwest of Mount Jackson, Mount Jackson (15') Quadrangle; dam on Shenandoah River, $1\frac{1}{2}$ miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle.

Same formation in Pennsylvania: 1 mile northwest of Guilford Springs, $2\frac{1}{2}$ miles southwest of Chambersburg, Chambersburg (15') Quadrangle; 1 mile south of St. Thomas, Mercersburg (15') Quadrangle.

Rodman formation in Pennsylvania: At Bellefonte, Bellefonte (15') Quadrangle.

Dark shale below Eureka quartzite in Nevada: On the north slope of hill 8167 on Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia County Road 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is characterized by its large size and strongly inflated pedicle valve, thus differing markedly from *B. virginiensis*. The Oranda species seems to be less swollen than *B. pisum* and is usually wider along the hinge than that species.

BILOBIA MUSCA (Öpik)

Plate 192, D, figures 21-24

Specimens of this species are introduced for comparison with the Appalachian species.

Types.—Hypotypes: 84258a-c.

Horizon and locality.—Kuckers formation (3ca): At Kohtla in Estonia.

BILOBIA PISUM (Ruedemann)

Plectambonites pisum RUEDEMANN, New York State Mus. Bull. 49, p. 19, pl. 1, figs. 8, 9, 12-15, 17-20. (10?, 11?, 16?), 1901.—BASSLER, Cambrian and Ordovician: Maryland Geol. Surv., p. 253, pl. 48, figs. 3-6 (1, 2?), 1919, repeats Ruedemann's description and figures.

This species has been widely but usually erroneously identified, because it has the form and sculpture of a number of other stocks of plectambonitids such as *P. scissa* Salter, *P. transversalis* (Wahlenberg), and *P. gibbosus* Winchell and Schuchert. It is another interesting case of heterochronous homeomorphy. The species as figured by Ruedemann appears to be composite and perhaps contains more than a single genus. Wide and narrow forms are represented which are probably conspecific, but the specimen represented by figures 10 and 11 has very different proportions from those given in the description and probably should be excluded from the species.

In comparison with *Bilobia hemisphaerica* Ruedemann's figures and specimens from the gray crystalline limestone (Rysedorf conglomerate) in the National Museum indicate that *B. pisum* is generally more strongly convex than the *Oranda* species and the pedicle muscle area is smaller. One of the Rysedorf specimens (fig. 17) has a curved furrow on the inside just anterior to the cardinal extremity. This feature also appears on specimens from Guilford Springs, Pa. It is less marked in the strongly rotund forms.

B. pisum comes from the black and gray crystalline limestone pebbles of the Rysedorf conglomerate according to Ruedemann.

BILOBIA VIRGINIENSIS Cooper, new species

Plate 192, A, figures 1-5; plate 192, B, figures 6-15; plate 195, B, figures 6-8

Small, tumid, semicircular in outline, wider than long and with the greatest width in the posterior half; sides moderately oblique to nearly straight. Anterior margin narrowly rounded. Surface marked by costellae of unequal size, valves differently marked. Pedicle valve with about 15 strong, threadlike costellae on the front margin but only a few of them reaching the umbo, spaces between larger costellae marked by a mat of fine costellae. Brachial valve covered by a mat of fine, nearly even costellae.

Pedicle valve strongly convex in anterior and lateral profiles; posterior slope steep and rounded; anterior slope longer but less steep than the posterior one; lateral slopes long and steep. Umbo moderately swollen; median region tumid. Interarea short, anacline.

Brachial valve deeply concave, with the maximum concavity just anterior to the middle; anterior sulcate; anterior margins strongly bent in the direction of the brachial valve. Cardinal extremities with short, narrow grooves to the exterior. Interarea short, hypercline. Lobes of visceral disk long and narrow.

Measurements in mm.—

| | Length | Brachial length | Surface length | Mid-width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------------|-----------|-------------|-----------|--------|
| Holotype | 6.9 | 5.0 | 11.5 | 8.0 | 8.2 | 2.8 | 4.0 |
| Paratype (117467c) .. | 6.9 | 5.6 | 11.5 | 8.1 | 8.0 | 2.7 | 3.9 |

Types.—Holotype: 117464a; figured paratypes: 117464b,c, 117465a,b, 117466a, 117467c; unfigured paratype: 117465c.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Virginia: Ravine at the switch just east of Strasburg Junction, Strasburg (15') Quadrangle; dam on north fork of the Shenandoah River, $1\frac{1}{2}$ miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle.

Botetourt formation in Virginia: On the south side of the road 0.2 mile east of Strasburg, Strasburg (15') Quadrangle.

Edinburg formation (lower *Nidulites* zone) in Virginia: From the cut on U. S. Highway 11, just southwest of entrance to Battlefield Crystal Caverns, 1 mile northeast of Strasburg; Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg; both in Strasburg (15') Quadrangle.

Shippensburg formation (Pinesburg member—*Echinosphaerites* zone) in Pennsylvania: In the railroad cut $2\frac{1}{2}$ miles southwest of Marion, Chambersburg (15') Quadrangle.

Same formation in Maryland: In the cut on U. S. Highway 40, on the west bank of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—*Bilobia virginiensis* can be recognized by its small size but strongly convex valves. It differs strongly from *B. pisum* and *B. hemisphaerica* in size and has a much less swollen umbo, less inflated pedicle valve, stronger and more crowded costellae. This species occurs in the *Cyrtonotella* zone and in the lower part of the *Nidulites* zone of the Edinburg formation.

Subfamily LEPTELLOIDINAE Cooper, new subfamily

Plectambonitidae with elevated visceral disk.

Genus LEPTELLOIDEA Jones, 1928

Leptelloidea JONES, Mem. Geol. Surv. Great Britain, Palaeont., vol. 1, No. 5, pp. 388, 392, 1928.

LEPTELLOIDEA LEPTELLOIDES (Bekker)

Plate 188, E, figures 25-30

The figures of this genus and species are introduced for comparison with *Leptellina*. Note difference in construction of cardinal process.

Types.—Hypotypes: 84257a-d.

Horizon and locality.—Kuckers formation (C_{2a}): At Kohtla in Estonia.

Family BIMURIIDAE Cooper, new family

Concavo-convex, smooth or lamellose Plectambonitacea with apical foramen in pedicle valve; simple cardinal process and 2 or 3 long divergent median septa in the brachial valve.

Genus BIMURIA Ulrich and Cooper, 1942

Bimuria ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 622, 1942.

Shell moderately large reaching a width of about an inch, semicircular to semi-elliptical in outline, concavo-convex in profile. Pedicle interarea curved, longer than the brachial one, anacline; brachial interarea hypercline. Delthyrium in well-preserved individuals partially closed by a short and rudimentary pseudo-deltidium. Beak perforated by a tiny foramen. Umbonal region generally smooth; more or less of remaining surface covered by thin, wrinkled shell lamellae. Shell structure pseudopunctate.

Pedicle interior with small, rudimentary teeth; dental plates obsolete; diductor and adjustor scars located at the base and sides of the delthyrial cavity; diductor scars large; adductor scars indistinct. Vascula media strong, extending to about the middle of an adult shell, then branching, the inner branches extending nearly to the margin, while the outer ones arch slightly and extend nearly to the margin where they again branch.

Brachial valve with elongate, slender, widely divergent brachial processes. Chilidial plates strongly developed, attached to brachial processes and sides of notothyrium by callus. Cardinal process simple, myophore slender or somewhat expanded, shaft short, united with a thin median septum that extends for nearly the full length of the valve and is located between 2 slightly divergent lateral septa. Lateral septa high and thin in the young, overgrown and nearly obliterated in old shells by callus deposit on their inner and outer sides. Adductor impressions somewhat flabellate, located on the posterior portion of the callus deposits on the outside of the lateral septa.

Genotype.—*Bimuria superba* Ulrich and Cooper, Journ. Paleont., vol. 16, No. 5, p. 623, pl. 90, figs. 13-18, 1942.

Discussion.—Species of this genus have been assigned to *Plectambonites* = *Sowerbyella* and *Christiania*. From the former it differs by its exterior and the presence of the longitudinal lamellae inside the brachial valve. No taxonomic relationship exists between *Bimuria* and *Sowerbyella*. *Bimuria* resembles *Christiania* in external form but is never so elongated as the species of that genus and is usually lamellose whereas *Christiania* is smooth. The brachial interior of *Bimuria* differs from that of *Christiania* in the possession of a simple cardinal process rather than a rafinesquinoid, bilobed process such as is present in *Christiania*.

Outside the United States in the Stinchar limestone of the Girvan District, Scotland, *Plectambonites* ? *youngiana* (Davidson) is referable to *Bimuria*.

BIMURIA BUTTSI Cooper, new species

Plate 212, B, figures 11-31

Christiania lamellosa Ulrich Ms. (not Bassler, 1919), BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 116, pl. 26, figs. 31-34, 1926.

Shell of about medium size for the genus, slightly wider than long; hinge less than the greatest width which is at the middle of old adults. Lateral margins gently convex; anterior margin broadly to narrowly rounded. Umbonal region of both valves usually smooth, remainder of surface covered by concentric lamellae.

Pedicle valve moderately convex in lateral and anterior profiles. Umbo swollen. Anteriorly from the umbo a distinct but low fold is developed which extends to the anterior margin and produces a shallow sulcus there. Lateral slopes moderately steep; posterolateral slopes abrupt and steep. Interarea strongly curved, anacline.

Brachial valve strongly concave with the greatest depth in the midregion; anterior portion sulcate; flanks bounding sulcus gently concave. Umbonal region deeply concave; interarea strongly hypercline.

Pedicle interior with small teeth, vascula media well impressed in adults; other pallial marks less distinct. Inside the brachial valve lateral and median septa well developed; adductors located on callosities, and fairly well impressed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Height |
|-----------------------------------|--------|-----------------|-------|-------------|-----------|--------|
| Holotype | 15.6 | 12.0 | 18.5 | 15.2 | 4.0 | 6.8 |
| Paratype (110932a with frills) .. | 18.4 | 15.0 | 21.9 | 16.2 | 4.7 | 9.2 |
| “ (110932b) | 14.4 | 11.0 | 15.6 | 12.3 | 4.0 | 6.9 |
| “ (110932c) | 10.9 | 8.9 | 11.9 | 13.0 | 2.2 | 5.0 |
| “ (71506b) | 17.3 | 14.0 | 18.8 | 16.3 | 3.7 | 7.6 |

Types.—Holotype: 110934a, figured paratypes: 71506a, 110930a-d, 110932a,e, 110933a,c-e, 110934b,c, 110935a, 123264; unfigured paratypes: 71506b, 110930e, 110931, 110932b-d, 110933b, 110935b-e.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile northeast of Pelham and 2 miles north of Pelham, Bessemer Iron District (15') Quadrangle; intersection of Bailey Gap road with main road $1\frac{3}{4}$ miles northeast of Newhope Church, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., Vandiver (15') Quadrangle.

Discussion.—The young of this species are generally considerably wider than long and with the hinge forming the greatest width. With increasing age the length increases at the expense of the width with the result that the old adult is generally subquadrate to subcircular in outline. The hinge with increasing age fails to grow laterally. Consequently, in adult shells the hinge does not form the widest portion of the valves.

This species suggests *B. superba* which it approaches in size, but it seldom attains the large subquadrate form of the Tennessee species. The development of a fold and sulcus are features lacking in *B. superba*. The fold and sulcus are seldom very prominent in *B. buttsi*, but they are, nevertheless, distinct. The

brachial interarea of *B. buttsi* is generally more hypercline than that of *B. superba*. Therefore, the chilidial plates and cardinal process are brought more fully into view in the Little Oak species.

BIMURIA IMMATURA Cooper, new species

Plate 211, A, figures 1-13

Shell small, about twice as wide as long in the adults, cardinal extremities rounded, auriculate. Anterior margin broadly rounded. Surface unornamented except for concentric lamellae of growth and fine thin lamellae that cover much of the shell.

Pedicle valve strongly convex with the greatest curvature in the region of the umbo. Median region swollen; anteromedian portion somewhat swollen. Front and lateral slopes moderately steep. Ears convex. Delthyrium very wide; interarea short and pseudodeltidium rudimentary. Foramen open, in the form of a short, oblique tube. Brachial valve deeply concave, following the curvature of the pedicle valve closely, deepest in the median region; front and lateral margins inflected toward the brachial valve; ears concave. Interarea short, almost orthocline in position. Chilidium short but wide. Umbo convex and forming a small knob at the center of the valve.

Interior of pedicle valve with short and wide teeth; dental plates absent; musculature not visible. Inside the brachial valve 2 high, thin septa arise not far anterior to the cardinalia, diverge gradually as they extend nearly to the front margin. A small, median septum, thick but short, located between the 2 lateral septa at their place of origin. Adductor muscles attached to elevated papillose callosities on the outside of the lateral septa. Brachial processes rudimentary, cardinal process absent.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 5.0 | ? | 6.3 | 7.0 | ? | 2.0 |
| Paratype (110976a)..... | 3.3 | 2.6 | 5.0 | 5.3 | 0.9 | 1.3 |
| " (110976h)..... | 3.1 | 2.5 | 5.0 | 4.7 | ? | 1.4 |
| " (110976k)..... | 5.1 | ? | 6.3 | 7.2 | ? | 1.9 |

Types.—Holotype: 110976g; figured paratypes: 110976i-k,m,n,p; unfigured paratypes: 110976a-f,h,l,o.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Botetourt formation in Virginia: 3 to 4 miles east-northeast of Blacksburg; 1.8 miles S. 4° W. of Bethel Church, 5.9 miles due east of Harrisonburg, Harrisonburg (15') Quadrangle.

Discussion.—This species is characterized by its small size, unornamented but lamellose shells, and siphonate foramen. All these characters suggest young *Bimuria*, but clear-cut evidence that such is the case has not been found. *Bimuria superba* occurs in the Effna formation, but intermediate stages between the largest of *B. immatura* and young *B. superba* have not been found. Further-

more, considerable uniformity of size has been observed in *B. immatura*. For these reasons it is preferred to regard the numerous specimens of this form in the collection as a distinct species.

In addition to *B. immatura* two other species like it are known: One from the Mystic conglomerate of Quebec, the other, *B. siphonata*, from the Pratt Ferry formation of Alabama. The former species, *B. matutina*, has a much more elevated umbo than the Effna form. Its interior is unknown, and it is possible that the species may not be related generically to *Bimuria*. The Alabama species differs in its slender, transverse outline.

BIMURIA LAMELLOSA (Bassler)

Plate 194, A, figures 1-10; plate 212, A, figures 1-10

Christiania lamellosa BASSLER, Cambrian and Ordovician: Maryland Geol. Surv., p. 257, pl. 49, figs. 3-10, 1919.—BUTTS, Virginia Geol. Surv. Bull. 52, p. 109, pl. 95, figs. 7-10, 1942.

Christiania trentonensis brevis BUTTS, idem, fig. 1.

Shell small for the genus, wider than long with the greatest width slightly anterior to the hinge. Cardinal extremities narrowly rounded. Lateral margins gently rounded; anterior margin broadly to narrowly rounded. Umbonal region of both valves smooth; remainder of surface marked by more or less distant concentric lamellae. Exfoliated shells appear to be smooth.

Pedicle valve strongly convex in lateral profile with the greatest convexity at about the middle. Anterior profile forming a semicircle. Umbo swollen; beak small, drawn into a sharp point. Foramen minute, located slightly posterior to the apex of the beak. Valve strongly inflated with steep lateral and postero-lateral slopes. Fold poorly defined, developed only in median region and near the front. Interarea curved, strongly anacline.

Brachial valve deeply concave with the greatest concavity about at the middle. Anterior to the middle a low, not well defined sulcus indents the commissure toward the brachial valve. Interarea well developed, hypercline to orthocline. Notothyrium closed by a thick and large chilidium.

Brachial processes widely divergent, thin, defining deep sockets for the teeth. Cardinal process a simple ridge, nearly obsolete and poorly defined in the extreme posterior part. A low ridge extends anterior to the rudimentary process nearly to the anterior margin. This ridge is highest at the place where the 2 divergent septa originate and extends between them. Outside each septum is a papillose lobate area on the posterior portion of which the adductor muscles were attached. The outside of these lobate areas is elevated above the floor of the valve.

Measurements in mm.—

| | Length | Brachial length | Hinge width | Width | Thickness | Height |
|------------------------|--------|-----------------|-------------|-------|-----------|--------|
| Lectotype | 10.4 | 7.7 | 11.7 | 10.9 | 2.2 | 5.2 |
| Paratype (66168c) | 10.7 | 8.1 | 11.9 | 10.0 | 2.5 | 4.6 |

Types.—Lectotype: 66168a; paratypes: 66168b-d; figured hypotypes: 110948a-c,f, 110949a,c.

Horizon and locality.—Oranda formation in Strasburg (15') Quadrangle, Virginia: In the railroad cut $\frac{1}{2}$ mile west of Strasburg; on U. S. Highway 11, from $\frac{1}{2}$ to 2 miles southwest of Strasburg; on Virginia Highway 55, 0.4 mile west of U. S. Highway 11, north edge of Strasburg.

Same formation in Pennsylvania: 1 mile northwest of Guilford Springs, $2\frac{1}{2}$ miles southwest of Chambersburg, Chambersburg (15') Quadrangle.

Discussion.—This species is more transverse and never attains the large size reached by *B. superba* and *B. buttsi*. It was originally confused with *Christiania* and under that term lent an erroneous name to a stratigraphic zone. Inasmuch as the Oranda formation is nearly synonymous with the *Christiania* or *Bimuria* zone, it is really not necessary to use the generic names.

Bimuria lamellosa is a fairly small species which will not be confused with *B. buttsi* or *B. superba*. It is not unlike *B. parvula* but differs in its larger size, stronger and more inflated umbo, and more completely lamellose exterior.

BIMURIA ? MATUTINA Cooper, new species

Plate 210, C, figures 6-10

Small, resembling *B. immatura*, wider than long with the greatest width at or near the hinge; sides oblique, gently rounded; anterior margin broadly rounded; surface smooth in the decorticated condition but showing traces of lamellae in distant, elevated concentric lines.

Pedicle valve moderately strongly convex, flattened in the anterior third and narrowly rounded on the umbo; anterior profile with median region strongly humped and with long, moderately steep and gently concave lateral slopes. Umbonal and median regions strongly swollen, the swelling continued anteriorly but in diminishing degree to the front margin. Sides depressed and with moderately steep anterolateral slopes. Foramen and interarea not observed; interior unknown.

Brachial valve deeply concave, with the deepest part at or just posterior to the middle. Concavity occupying most of valve and resulting anterior margin strongly reflected in the direction of the brachial valve. Cardinal extremities concave. Interior unknown.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 4.9 | ? | 6.5 | 7.7 | ? | 2.3 |
| Paratype (66288a) | 5.7 | ? | 8.3 | 8.8 ? | ? | 2.1 |
| " (66288c) | ? | 4.1 | 6.7 | 7.4 | ? | ? |

Types.—Holotype: 66288b; figured paratype: 66288a; unfigured paratypes: 66288c-g.

Horizon and locality.—Boulder in the Mystic Conglomerate in Canada: On Range 6, Lot 20, Stanbridge Township, near Mystic, Quebec.

Discussion.—This is a small species occurring in fairly hard limestone boulders in the Mystic conglomerate. The matrix has defied preparation of pedicle interiors because the internal details of that valve are only lightly impressed at best in other species of *Bimuria* comparable to this one. No specimens of the brachial valve appear in the collection except ones preserving an impression of the exterior. It was thus impossible to obtain the brachial interior by burning off the shell.

This species is most like *B. immatura* but differs in attaining a larger size than any yet noted for the Virginia species. The median swelling is narrower than that of *B. immatura* and the flanks thus more depressed. The flanks are also somewhat narrower than in the Virginia species. The Quebec species is larger than, and different in shape from, *B. siphonata* from Alabama.

BIMURIA PARVULA Cooper, new species

Plate 184, B, figure 4; plate 210, A, figures 1-4

Small for the genus, wider than long, with the greatest width at about the middle; sides gently convex; anterior margin broadly rounded; anterior commissure narrowly sulcate. Width of hinge slightly less than the maximum shell width; surface mostly smooth but anterior half of some specimens showing traces of thin lamellae.

Pedicle valve strongly convex in lateral profile and with a swollen umbo which is the most convex part; anterior profile broadly and strongly convex with moderately long and steep lateral slopes. Median region swollen; anterior slope long and moderately sloping; posterior slope narrowly rounded; beak visible only from the brachial side, foramen small in the adult, produced into a short, narrow tube in the young adult and immature shell. Interior with wide, short teeth; muscle area not discernible. Interarea short, anacline.

Brachial valve deeply concave, the maximum concavity located just posterior to the middle; lateral regions less shallow than the median region; posterolateral areas somewhat flattened. Interior with widely divergent brachial process; median septum highest in the posterior third or quarter; lateral septa strongly elevated and with thick callosities on the side away from the middle.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 5.2 | 3.6 | 7.2 | 6.1 | 1.5 | 2.3 |
| Paratype (117469a)..... | 7.0 | ? | 8.8 | 6.8 | ? | 2.8 |
| “ (117469b)..... | 6.1 | 4.9 | 7.7 | 6.6 | 1.5 | 2.5 |

Types.—Holotype: 117469d; figured paratypes: 117469e,f, 123253a; unfigured paratypes: 117469a-c.

Horizon and locality.—Chatham Hill formation in Virginia: On northwest slope of Walker Mountain, 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Edinburg limestone (*Cyrtonotella* zone) in Virginia: On the south side of

the road, 0.2 mile east of Strasburg; about $\frac{1}{8}$ mile south of Strasburg Junction; ravine at switch just east of Strasburg Junction; all in Strasburg (15') Quadrangle. Collier Creek, $\frac{1}{2}$ mile north of the junction of Virginia County Highways 251 and 612, about 6 miles west-southwest of Lexington, Rockbridge County.

Shippensburg formation (lower 50 feet above New Market limestone) in Pennsylvania: In the field just north of the east end of the railroad cut 2 miles southwest of Marion Station, Chambersburg (15') Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: Cut at the crossing of U. S. Highway 50 over Opequan Creek, southeast of Winchester, Winchester (15') Quadrangle.

Discussion.—This species, although small in size, is larger than *B. immatura*, *B. matutina*, or *B. siphonata*. It is really intermediate between these and *B. lamellosa*. It is not so strongly umbonate as the latter and is generally not so strongly or so completely lamellose as the *Oranda* species. It is much smaller in size than either *B. buttsi* or *B. superba*.

BIMURIA SIPHONATA Cooper, new species

Plate 210, G, figures 17-24

Shell small, transversely semielliptical, with the hinge equal to or slightly less than the greatest width; posterolateral extremity somewhat rounded; sides gently rounded, somewhat oblique; anterior margin broadly rounded; posterior half to three-quarters usually smooth, anterior half to quarter often with thin concentric lamellae.

Pedicle valve strongly and fairly evenly convex in lateral profile, the umbo forming the most rounded part; anterior profile forming a strongly convex, broad arch with evenly and moderately steeply sloping sides. Umbo swollen; median region and sides strongly inflated giving the entire valve a fairly even convexity; beak provided with a narrow siphon projecting directly posteriorly or inclined somewhat toward the pedicle valve and narrowing distally to form a tiny foramen; delthyrium open; muscle impressions too lightly impressed to be discernible or individualized.

Brachial valve deeply and broadly concave, sharing the even convexity of the pedicle valve; interarea with rudimentary chilidial plates and a small transverse, flat plate at the apex. Cardinal process not formed; brachial processes slender, extending along edge of palintrope; median septum short, highest at point where lateral septa originate a short distance anterior to the apex; lateral septa low, moderately divergent and extending onto anterior slope; adductor scars located outside the septa and forming fimbriated lobe which is divided unevenly by a low, oblique ridge.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Thickness | Height | Length of siphon |
|-----------------------|--------|-----------------|-----------|-------------|-----------|--------|------------------|
| Holotype | 2.0 | 1.9 | 4.4 | 4.4 | ? | 0.9 | 0.25 |
| Paratype (117470d) .. | 2.6 | 2.0 | 5.0 | 5.4 | ? | 1.5 | 0.40 |

Types.—Holotype: 117470a; figured paratypes: 117470d,e; unfigured paratypes: 117470b,c,f.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is suggestive of *B. immatura* and *B. matutina* in its small size and apparently immature characters. It differs from both of them, however, in the form and outline of the pedicle valve. The Quebec and Virginia species are strongly swollen medially and have somewhat depressed sides, particularly *B. matutina*. The species from the Effna limestone is somewhat nasute and is much less transverse than the *B. siphonata*.

Bimuria siphonata shows immature characters in its small size, lack of thickening of the adductor muscle field, and the presence of a pedicle siphon. The Pratt Ferry limestone to date has not yielded a normal adult of *Bimuria*, but hundreds of valves of about the same size of *B. siphonata* have been obtained from it. These facts suggest that the species may actually be an adult which retains some of its juvenile characters.

BIMURIA SUPERBA Ulrich and Cooper

Plate 184, C, figure 5; plate 210, B, figure 5; plate 210, F, figures 15, 16;
plate 210, I, figures 33, 34; plate 211, B, figures 14-25

Bimuria superba ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 623, pl. 90, figs. 13-18, 1942.

Christiania cf. *C. lamellosa* BUTTS (not Bassler), Virginia Geol. Surv. Bull. 52, p. 42, pl. 73, figs. 34-36, 1942.

Shell large, subcircular in outline, varying from slightly wider than long, to slightly longer than wide; cardinal extremities varying from a right angle to a slightly obtuse angle. Lateral margins nearly straight to gently convex; anterior margin broadly rounded. Profile concavo-convex with the pedicle valve strongly convex and its beak overhanging the brachial interarea. Surface generally nearly completely covered by fine, wrinkled, crowded, concentric lamellae.

Pedicle valve strongly convex in lateral profile and with the greatest convexity at about the middle. Umbo strongly swollen. Anterior profile strongly convex. Lateral and anterior slopes abrupt and steep. Posterolateral slopes steep and slightly concave. Interarea strongly concave, anacline in position.

Brachial valve deeply concave with the greatest concavity at about the median region. Interarea strongly hypercline. Umbonal and median regions deeply concave.

Interiors as described for the genus.

Measurements in mm.—Holotype, length 19.7, brachial length 14.8, width 22.2, hinge width 18.4, thickness 5.4, height 8.5.

Types.—Holotype: 108200a; figured paratypes: 108200b,c,f, 108201; unfigured paratypes: 108200d,e,g-j; figured hypotypes: 110964a, 110981, 117471, 117472a.

Horizon and locality.—Arline formation in Tennessee: On both sides of old

road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; $\frac{1}{4}$ mile south of McMullens, Meadow (T.V.A. 139-NW) Quadrangle; 1,500 feet south of the mouth of Burnett Creek, Shooks Gap (T.V.A. 147-NE) Quadrangle; small quarry $\frac{1}{2}$ mile northeast of St. Clair, Bulls Gap (T.V.A. 171-SE) Quadrangle; 1 mile northeast of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle; 6 to 10 miles southeast of Loudon; $5\frac{1}{2}$ miles southeast of Knoxville.

Tellico formation in Tennessee: On the south side of Chapman Highway (Tennessee Highway 71), 0.3 mile N. 10° W. of Pitner School, Walden Creek (T.V.A. 156-SW) Quadrangle.

Arline formation in Virginia: In the quarry at the railroad station in Marion, Marion (T.V.A. 218-SE) Quadrangle.

Botetourt formation in Virginia: On Virginia Highway 114, 2.3 miles west of the Montgomery-Roanoke County line, 12 miles northeast of Blacksburg.

Effna formation in Virginia: In Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—*Bimuria superba* is the largest of the known American species of *Bimuria*. It is characterized by its large size, attaining nearly an inch in width, and its generally subquadrate form. Its nearest relative is *B. buttsi* from which it differs in not having the wide hinge and oblique sides in the younger stages and by attaining a larger size than that reached by *B. buttsi*. The umbo of *B. superba* is not so elevated and narrowly convex as that of *B. buttsi*.

BIMURIA sp. 1

Plate 210, E, figures 12-14

A single fragmentary specimen of moderate size was found in the dark shaly rock under the Eureka quartzite on the north-facing nose of hill 8167, Martins Ridge, Monitor Range, Nev. The specimen is somewhat suggestive of *B. lamellosa* Bassler, but it is not well enough preserved to be definitely so identified.

Figured specimen.—117473.

CRASPEDELIA Cooper, new genus

(Greek *kraspedon*, border of a garment)

Shell small, resembling small *Bimuria*; strongly concavo-convex; transverse and with the hinge equal to or greater than the widest part; surface smooth; pseudopunctate.

Pedicle valve with swollen umbo and median region; foramen produced into a short siphon; interarea short, anacline; teeth short and wide; dental plates absent; other details of the interior not discernible. Anterior margin deflected toward the pedicle valve to form an elevated rim that fits inside a similar rim on the brachial valve.

Brachial valve with anterior margin deflected in the direction of the pedicle valve to form a high rim which fits outside the edge of the pedicle valve; interarea hypercline; chilidial plates small. Brachial process small, widely divergent and adhering closely to the palintrope edge. Median septum rising to a crest a

short distance anterior to the cardinalia, extended anteriorly as a low ridge or dying out; lateral septa narrowly divergent anteriorly, an elevated and anteriorly fimbriate adductor platform appearing on the outside of the septa.

Genotype.—*Craspedelia marginata* Cooper, new species.

Discussion.—This genus is closely related to *Bimuria* as shown by the interior structure of both valves. Pedicle valves show a suggestion of a siphonate foramen, but the specimens are more adult in their characters than *B. immatura* and *B. siphonata* with which it occurs. The deflected margins are clearly an adult character, and the genus may be regarded as an arrested off-shoot of the main *Bimuria* stock.

The interior of the brachial valve in its adductor callosities also suggests an adult shell. These callosities are elevated in some instances to the same degree as the visceral disk of *Leptellina* and *Bilobia*. In this respect *Craspedelia* differs strongly from *Bimuria*. It is interesting to note that the adaptation of this shell as exhibited by the deflected margins is very much like *Xenambonites*.

CRASPEDELIA MARGINATA Cooper, new species

Plate 213, A, figures 1-20

Shell small, transverse with the hinge forming the widest part; cardinal extremities alate; lateral margins strongly oblique, gently convex; anterior margin broadly rounded. Surface smooth.

Pedicle valve strongly convex in lateral profile and with the maximum convexity at the umbo; anterior profile strongly humped in the middle with steep slopes to the depressed flanks. Median region narrowly swollen and much elevated above the narrow, gently convex flanks. Marginal deflection not strongly elevated. Region immediately posterior to deflected rim forming a narrow trough.

Brachial valve deeply concave in the median region; lateral extremities sulcate but shallow; anterior part bounding concave median area steeply deflected toward the margin of the brachial valve; anterior margin deflected toward the pedicle valve, the deflected area attaining a length of more than 1 mm. Deflected margin enclosing the similar area in the pedicle valve.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Height | Length of deflected rim |
|----------|---------------|--------|--------------------|----------|----------------|--------|----------------------------------|
| Paratype | (117474a).... | 4.4 | ? | 6.6 | 7.4 | 2.0 | 0.75 |
| " | (117474g).... | 3.1 | ? | 5.0 | 6.2 | 1.9 | 0.90 |
| " | (117474n).... | ? | 3.1 | 6.0 | 7.0 ? | ? | 1.70 |

Types.—Holotype: 117474b; figured paratypes: 117474a,c-f; unfigured paratypes: 117474g-o.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is like *Bimuria matutina* or *B. immatura* in the exterior form of the pedicle valve but differs in having the strong anterior rims. It differs internally from *B. immatura* in the different development of the callosities of the adductor field.

Family SOWERBYELLIDAE Öpik, 1930

Plectambonitacea having a simple cardinal process united to the brachial processes, giving the cardinalia the shape of an inverted V.

Subfamily SOWERBYELLINAE Öpik, 1930

Sowerbyellidae having 2 or more septa in the brachial valve.

Genus SOWERBYELLA Jones, 1928

Sowerbyella JONES, Mem. Geol. Surv. Great Britain, Paleont., vol. 1, No. 5, pp. 384, 392, 1928.

SOWERBYELLA AEQUICOSTELLATA Cooper, new species

Plate 199, B, figures 9-17

Moderately large, length equal to about two-thirds the width. Cardinal extremities somewhat rounded, slightly acute or approximating a right angle. Lateral margin gently convex; anterior margin broadly rounded. Anterior commissure rectimarginate. Surface multicostellate; costellae narrowly rounded, separated by narrower interspaces. Costellae of nearly equal size. A few stronger than the surrounding ones are scattered on the surface. Costellae numbering about 24 to 30 in 5 mm. at the front margin.

Pedicle valve strongly convex in lateral profile and with the greatest convexity posterior to the middle. Anterior profile with the greatest convexity at the middle and with the lateral slopes flat and moderately steep. Beak inconspicuous, protruding very slightly beyond the posterior margin. Umbonal and median region inflated. Lateral areas moderately inflated with the slopes to the cardinal extremities short and moderately steep. Interarea long, curved, gently anacline.

Brachial valve moderately concave with the greatest concavity at about the center but becoming concave anteriorly. Flanks gently concave. Interarea moderately long, hypercline.

Interior: Pedicle valve with median ridge separating diductors short and stout, expanding anteriorly; diductor impressions large, widely divergent; adductor impressions small. Cardinal process of brachial valve large, septa low, strongly elevated at about the middle of the valve; adductor impressions thickened to form a low platform. Anterior half strongly spinose.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|-------|-------------|-----------|--------|
| Holotype | 9.2 | 7.7 | 13.2 | 13.2 | 2.0 | 3.0 |
| Paratype (117477a)... | 7.3 | ? | 11.7 | 12.2 | ? | ? |
| " (117477b)... | 8.6 | ? | 13.7 | 13.5 | ? | ? |
| " (117477c)... | 8.0 | ? | 13.2 | 13.6 | ? | ? |
| " (117477d)... | ? | 8.7 | 14.3 | 14.5 | ? | ? |
| " (117477g)... | 8.5 | 7.1 | 13.4 | 12.6 | 2.6 | 3.5 |

Types.—Holotype: 117477f; figured paratypes: 117476a, 117477a,b,d,e,g; unfigured paratypes: 117476b-d, 117477c,h.

Horizon and locality.—Edinburg formation (*Cyrtonotella* bed) in Strasburg (15') Quadrangle, Virginia: In the ravine at the switch $\frac{1}{8}$ to $\frac{1}{4}$ mile east of Strasburg Junction; Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg.

Edinburg formation (*Nidulites* zone) in Strasburg (15') Quadrangle, Virginia: On U. S. Highway 11 about 1 mile north of Strasburg; along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg.

Shippensburg formation (50 feet above base of Pinesburg member) in Maryland: On U. S. Highway 40, on the west bank of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Same formation in Pennsylvania: At the east end of the railroad cut and adjacent field to the north, $2\frac{1}{2}$ miles southwest of Marion, Chambersburg (15') Quadrangle.

Discussion.—Moderately strong and subequal costellae characterize this species. The shell is generally of moderate size and fairly low convexity. It is most like *S. cava* from the Oranda and Salona formations but differs in attaining a somewhat greater size, interareas less bent anteriorly, and considerably less convexity. This is not a common species in the lower Edinburg formation.

SOWERBYELLA AEQUISTRIATA (Willard)

Plate 197, C, figures 25-34

Plectambonites aequistriatus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 276, pl. 3, figs. 8, 9, 1928.

About medium size for the genus, wider than long, semielliptical in outline; cardinal extremities nearly a right angle and with the extremities drawn into tiny ears. Sides nearly straight to gently rounded; anterior margin broadly but strongly rounded. Costellate, costellae at front of pedicle valve generally alternating large and fine but on brachial valve usually more equal in size. About 5 costellae to the millimeter on the pedicle valve and 7 to the millimeter at the front margin of the brachial valve.

Pedicle valve evenly and gently convex in lateral profile, with the maximum convexity at about the middle; anterior profile with the median region somewhat narrowly convex but with the sides descending in long, only moderately steep slopes to the margins. Beak small, umbo narrowly swollen and with the swelling continued anteriorly as a poorly defined fold. Flanks flat to gently concave. Interior with the diductor scars diverging at about 80° and separated by a short median ridge.

Brachial valve gently concave; umbo concave, the concavity extended anteriorly as a shallow and narrow sulcus; flanks gently concave. Interior with septa slightly divergent and forming a crest at about two-thirds the length from the beak. Adductor field thickened at the front.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Hypotype (117478f) .. | 9.3 | 8.6 | 13.0 | 13.2 | 1.7 | 2.5 |
| " (117478g) .. | 9.9 | 9.1 | 14.8 | 17.1 | 2.0 | 3.8 |
| " (117478a) .. | 10.4 | 9.7 | 13.2 | 14.1 | 1.8 | 2.5 |

Types.—Figured hypotypes: 117478a,b,f,g; unfigured hypotypes: 117478c-e.

Horizon and locality.—Wardell formation in Tennessee: Along the railroad just west of Liberty Hill, Dutch Valley (T.V.A. 154-SE) Quadrangle; 0.3 mile east of Mason's store, Bristol (30') Quadrangle; near the south end of Chickamauga Dam, 7 miles upstream from Chattanooga, East Chattanooga (T.V.A. 112-SW) Quadrangle.

Discussion.—This species is characterized by a subrectangular to subquadrate outline, fine costellae, and moderate convexity, and is like several others found in the Appalachian Valley. The ornamentation and proportions are like those of *S. multcostellata*, but the size attained is generally greater than that reached by the latter species. *S. multcostellata* is usually a much deeper shell. *Sowerbyella socialis* approaches this species in form but is more strongly costellate and has a more prominent development of the beaded costellae. *Sowerbyella lebanonensis* does not attain the large size nor the somewhat quadrate form of *S. aequistriata*.

SOWERBYELLA ANGULATA Cooper, new species

Plate 206, A, figures 1-7

Sowerbyella curdsvillensis Burts (not Foerste), Alabama Geol. Surv., Special Rep. 14, p. 130, pl. 33, figs. 5, 6, 1926.

Shell large for the genus, subrectangular in outline; hinge forming widest part; cardinal extremities acutely angular to auriculate; sides oblique; anterolateral extremities broadly rounded; anterior margin nearly straight; costellae strong, not strongly differentiated in size at the front margin, 3 to 5 in a millimeter at the front margin. A few strong wrinkles along the posterior margin.

Pedicle valve strongly convex in lateral profile and with the maximum convexity in the median region; anterior profile strongly and broadly arched; lateral slopes moderately long and steep; beak and umbo inconspicuous; median region strongly swollen; anterior slope convex and steep; median region marked by a narrow, indistinct median fold. Interarea long and strongly apsacline; pseudodeltidium short.

Brachial valve deeply concave in the median region, the concavity lessening laterally; posterolateral extremities somewhat flattened.

Pedicle interior with broad diductor scars bounded posterolaterally by moderately strong ridges. Brachial interior with 3 strong median septa, the median one almost as prominent as the lateral ones. Subperipheral rim not strongly thickened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 12.5 | 11.3 | 18.2 | 22.6 | 3.5 | 5.4 |
| Paratype (71538b) | 12.3 | 11.1 | 18.3 | 20.7 | 3.2 | 4.5 |
| " (71538c) | 11.1 | 9.8 | 17.9 | 19.4 | 3.1 | 4.6 |
| " (117479a) | 10.6 | 9.5 | 16.9 | 20.5 | 3.0 | 4.5 |
| " (117479b) | ? | 9.4 | 17.5 | 19.0 | ? | ? |

Types.—Holotype: 71538a; figured paratype: 117479b; unfigured paratypes: 71538b,c, 117479a,c-e.

Horizon and locality.—Hermitage formation in Alabama: On Cliff Avenue, Clifton Terrace, Birmingham, Birmingham Special (15') Quadrangle.

Discussion.—This species is characterized by its transversely subrectangular outline, angular cardinal extremities and somewhat truncated front margin. It is obviously related to *S. curdsvillensis* but differs importantly from that species. It is more angulated in appearance, is much more convex and therefore with a more deeply concave brachial valve.

SOWERBYELLA BELLARUGOSA Ulrich and Cooper

Plate 196, E, figures 27-29

Sowerbyella bellarugosa ULRICH and COOPER, Geol. Soc. Amer. Special Pap. 13, p. 186, pl. 38A, figs. 1-3, 1938.

Types.—Lectotype: 92867e; paratypes: 92867a-d,f-1.

Horizon and locality.—Upper Pogonip group in Nevada: Ikes Canyon, Toquima Range, Roberts Mountains (1°) Quadrangle.

SOWERBYELLA CAVA Cooper, new species

Plate 203, C, figures 21-30; plate 203, D, figures 31-43

Sowerbyella sp. ? Virginia Geol. Surv. Bull. 52, pt. 2, p. 109, pl. 95, figs. 18-21, 1942.

Small, strongly convex, length about two-thirds the width; hinge equal to or slightly less than the greatest width; sides gently rounded, moderately oblique to nearly straight depending on age; cardinal extremities somewhat rounded or nearly a right angle. Anterior margin broadly rounded, often faintly nasute. Costellae variable on both valves, those of the brachial valve appearing closely crowded, those of the pedicle valve somewhat more distantly spaced. Costellae of unequal size and unequal in spacing, a larger and smaller one alternating or 3 or 4 alternating with larger costellae. About 5 or 6 costellae to the millimeter at the front margin of an adult.

Pedicle valve strongly convex in lateral profile and with the maximum convexity at about the middle; anterior profile strongly convex in the median region and with steeply sloping sides. Umbo low, somewhat swollen and in many specimens forming a low, narrow fold more or less indistinctly extending to the anterior margin; median region of middle and anterior parts of valve strongly swollen; sides steep; anterior slope long and steep; posterolateral extremities only slightly flattened. Interarea gently anacline. Pseudodeltidium short. Beak visible from the side of the brachial valve, protruding slightly over the interarea.

Brachial valve deeply concave especially from the umbo to the front margin which is slightly indented; umbo deeply concave; anterior and lateral portions dipping steeply toward the middle; posterolateral extremities gently concave. Interior with slightly divergent septa rising to a high crest at midwidth; anterior slope of crest steep; muscular field transversely elliptical; lateral scars the larger; inner margin thickened and strongly granulose just inside the periphery.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 8.8 | 7.4 | 12.3 | 12.3 | 2.3 | 4.2 |
| Paratype (117481a) .. | 8.6 | 7.4 | 11.9 | 13.0 | 2.4 | 3.9 |
| " (117481c) .. | 7.5 | 6.3 | 10.8 | 11.4 | 2.0 | 3.4 |
| " (117481d) .. | 7.4 | 6.2 | 10.3 | 10.6 | 2.0 | 3.6 |
| " (117481e) .. | 8.3 | 6.8 | 11.1 | 11.0 | 2.3 | 3.8 |

Types.—Holotype: 117481b; figured paratypes: 117480a, 117481a,e,f; 123258a-c; unfigured paratypes: 117480b-d, 117481c,d.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle; along the railroad $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle; just west of the junction of Virginia County Highways 617=910, and 777, $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle.

Basal Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia County Highway 617=910, 0.15 mile north of Green Mount Church, 4 to 5 miles north of Harrisonburg, Broadway (15') Quadrangle.

Salona formation in Pennsylvania: On Fishing Creek, north edge of Salona, Lock Haven (15') Quadrangle.

Discussion.—This species suggests *S. aequicostellata* in its general configuration and ornamentation. The two species also occur in faunas that are obviously related. *Sowerbyella cava* is much more convex, is less transverse, and has more prominent cardinal extremities than *S. aequicostellata*.

SOWERBYELLA COMPACTA Cooper, new species

Plate 196, H, figures 51-59; plate 197, B, figures 11-24; plate 200, A, figures 1-6;
plate 202, A, figures 1-8

Shell about medium size for the genus, wider than long with the length equal to about two-thirds the width. Cardinal extremities slightly acute or approximately rectangular, often auriculate. Lateral margins indented just anterior to the cardinal extremities, extending nearly straight or moderately obliquely to the anterolateral margins; anterior margin broadly curved. Anterior commissure rectimarginate to sulcate. Surface ornamented by costellae of nearly equal size, about 120 in number and 6 or 7 in 1 mm. at the front margin of an adult. In addition to these the costellae are provided with small crescentic beads and the interspaces are marked by fine concentric fila; on each side of the beak and just anterior to the posterior margin many specimens show 4 or 5 oblique wrinkles.

Pedicle valve having a moderate convexity in lateral profile with the greatest convexity at about the middle; in anterior profile it forms a low arch highest in the middle and with the sides sloping moderately steeply to the margins. Beak inconspicuous, umbo narrowly swollen, produced forward as a more or less distinct fold that may or may not reach the anterior margin. Valve full in mid-region, slopes to anterior and lateral margins moderately steep. Interarea slightly curved, moderately long and strongly apsacline. Pseudodeltidium small.

Brachial valve moderately concave with the most concave portion between the umbo and the middle; posterolateral areas deflected and flattened. Areas bounding deepest concave portion only gently convex. Median sulcus reaching the margin in some specimens, in others the anterior portion distinctly flattened. Interarea hypercline.

Pedicle interior with large, subflabellate, widely divergent adjustor-adductor impressions; median septum short, forked. Interior thickened and with deeply impressed pallial marks. Brachial valve with much thickened and wide peripheral border; median septa low, ending at about middle of valve where they are moderately elevated.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|-------|-------------|-----------|--------|
| Holotype | 6.9 | 6.6 | 10.2 | 11.1 | 1.4 | 2.0 |
| Paratype (117487b)... | ? | 6.7 | 9.3 | 9.1 | ? | ? |
| " (117487c)... | 7.6 | 7.1 | 10.5 | 10.7 | 1.8 | 2.5 |
| " (117487d)... | 7.8 | 7.3 | 10.5 | 11.1 | 2.0 | 2.2 |
| " (117487e)... | 6.9 | 6.6 | 9.9 | 10.3 | 1.8 | 2.1 |
| " (117487f)... | 7.0 | 6.5 | 9.4 | 9.3 | 1.8 | 1.9 |
| " (117489a)... | 7.8 | 7.4 | 11.9 | 12.4 | 1.8 | 2.9 |
| " (117486a)... | 7.2 | 6.6 | 11.2 | 12.5 | 1.6 | 2.2 |
| " (117486c)... | 6.6 | 6.3 | 10.0 | 11.7 | 1.3 | 2.1 |
| " (117484a)... | 6.0 | 5.6 | 8.2 | 8.7 | 1.5 | 1.8 |
| " (117484b)... | 7.2 | 6.6 | 9.0 | 9.5 | 2.3 | 2.6 |
| " (117483b)... | 8.4 | ? | 12.0 | 12.6 | ? | 2.5 |
| " (117483a)... | ? | 8.0 | 12.8 | 14.3 | ? | ? |
| " (117483f)... | 8.3 | ? | 12.4 | 13.3 | ? | 2.4 |
| " (117483e)... | ? | 8.1 | 12.8 | 12.6 | ? | ? |
| " (117490).... | 8.6 | 8.0 | 12.3 | 12.8 ? | 1.9 | 2.5 |

Types.—Holotype: 117487a; figured paratypes: 117483b,c, 117484a-d, 117485a,b, 117486a-c, 117487b, 117490; unfigured paratypes: 117482, 117483a, d-f, 117487c-i, 117489a.

Horizon and locality.—Benbolt formation in Virginia: 1 mile west of Rye Cove, second cut west of McDavid's house; 0.3 mile north-northwest of the Memorial School, Rye Cove; at the Brick Church $1\frac{1}{2}$ miles west of Rye Cove; 1 mile west of Rye Cove; Clinchport (T.V.A. 188-NW) Quadrangle. 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles due south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; north side of U. S. Highway 19, $1\frac{3}{4}$ miles south-east of Hansonville Post Office, Brumley (T.V.A. 205-SE) Quadrangle; east bank of sinkhole 300 feet south of Lakeview Church, on Virginia Highway 71, Moll Creek (T.V.A. 196-SE) Quadrangle.

Dryden formation in Tennessee: Lone Mountain, 1 mile west of Lone Mountain, and $1\frac{1}{2}$ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; Tennessee Highway 53 at Nicely and Palmer's store, $\frac{1}{2}$ mile east of Kate, Maynardville (30') Quadrangle. Roadside 0.9 and 1.6 miles northeast of Heiskell; road corner $\frac{1}{2}$ mile southwest of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle. West side of sharp loop of the road down Flint

Creek, center subquad., Powder Springs (T.V.A. 154-SW) Quadrangle; Sycamore Creek, northwest corner Maynardville (T.V.A. 145-SE) Quadrangle; north side of Lone Mountain Creek, just west of the road to Straight Creek, 0.8 mile west of Lone Mountain Station, Tazewell (T.V.A. 154-NE) Quadrangle.

Type Ottosee shale (= Benbolt formation) in Tennessee: At Chilhowee Park, north side of Knoxville, Knoxville (T.V.A. 147-NW) and Fountain City (T.V.A. 146-SW) Quadrangles.

Discussion.—This is a somewhat variable species, some of the specimens having a fairly quadrate form whereas others are distinctly subrectangular. The species is characterized by moderate convexity and concavity, the common sowerbyelloid habit, but marked by very fine costellae, 6 or 7 to the millimeter. The species is much like *S. socialis* in form and contours but differs in having much finer costellae. *Sowerbyella lebanonensis* is suggestive of this species but has costellae more distinctly differentiated into fine and strong and is a more transverse shell having a length/width index of 0.62 to 0.67, whereas that of *S. compacta* is 0.64 to 0.80 and with an average near 0.70.

SOWERBYELLA CURDSVILLENSIS (Foerste)

Plate 201, A, figures 1-13

Plectambonites curdsvillensis FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 17, p. 122, pl. 10, figs. 15A, B, 1912.

In describing this species Foerste failed to give any details of the exterior. His description emphasizes the subperipheral border and the small pallial distributaries extending anteriorly on its surface. This species is a large form with beaded costellae like *S. punctostriata*. The following characters of the exterior are important: Wider than long, with the cardinal extremities nearly a right angle; auriculate in the young; subrectangular; sides nearly straight to moderately oblique; anterior margin broadly rounded to nearly straight. Pedicle valve fairly strongly convex in lateral profile; broadly convex in anterior profile; lateral slopes long and moderately steep. Brachial valve moderately deeply concave; flanks gently concave to somewhat flattened.

Inside the pedicle valve the diductor scars are long and separated by a median ridge extending nearly to the valve middle; vascula media broad. Brachial interior usually with thickened subperipheral rim, well-defined septa and wide adductor field with elevated rim marking its outer boundaries.

Types.—Figured hypotypes: 117491b,c,e,g-i; unfigured hypotypes: 117491a,d,f.

Horizon and locality.—Curdsville formation in Kentucky.

Basal Martinsburg formation (=Curdsville): Along the Cumberland front and elsewhere in Virginia and Tennessee.

Discussion.—The differences between this species and *S. punctostriata* are discussed on page 792. The two species are sufficiently close to be ecads of a single species, but larger collections than those available in this study will be necessary to demonstrate the point.

SOWERBYELLA EXIMIA Cooper, new species

Plate 204, C, figures 13-33; plate 205, B, figures 7, 8

Large for the genus, length two-thirds the width; cardinal extremities varying from slightly alate to slightly obtuse; sides gently rounded, slightly oblique to nearly straight; anterior margin ranging from broadly rounded to somewhat truncated. Ornamentation of the same type as that of *S. punctostriata*, consisting of costellae of unequal size, from 1 to 5 fine costellae separated by stronger ones; about 30 costellae in 5 mm. at the front margin. Costellae beaded. Posterior margin of both valves with oblique wrinkles.

Pedicle valve having an uneven lateral profile, the greatest convexity located just anterior to the umbo, anterior profile broadly triangular, the median crest somewhat narrowly rounded but the sides long and flat and dipping only moderately steeply. Umbonal region gently inflated; fold low, indistinct, extending from umbo to anterior margin but not clear in all specimens. Median region gently inflated. Interior with oval diductor patches and short median septum. Inner surface strongly papillose. No strong vascula media extending from diductor scars.

Brachial valve moderately concave, most concave in the umbonal and median regions, the concavity forming a sort of sulcus; flanks gently concave toward the median region but flattening laterally and anteriorly. Posterolateral extremities flattened. Interior with large muscle field but with septa low and delicate, reaching a crest at about the middle of the valve. Inner surface papillose particularly the broad, gently sloping area anterior to the septa.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 10.0 | 9.4 | 16.5 | 16.5 | 1.8 | 3.1 |
| Paratype (117492b) .. | 11.7 | 10.8 | 19.0 | 18.8 | 2.1 | 3.9 |
| " (117492c) .. | 11.5 | 10.6 | 16.7 | 16.0 | 2.4 | 3.5 |
| " (117492h) .. | 8.9 | 8.2 | 14.3 ? | 14.6 | 1.7 | 3.0 |
| " (117492j) .. | 10.7 | 9.6 | 16.0 | 16.3 | 2.6 | 3.9 |
| " (117492k) .. | 8.4 | 7.9 | 13.4 | 14.6 | 2.2 | 3.1 |

Types.—Holotype: 117492a; figured paratypes: 117492c,d,f,h,j,k,n,p; unfigured paratypes: 117492b,e,g,i,l,m,o,q,r.

Horizon and locality.—Oranda formation in Virginia: Just west of junction of Virginia County Highways 617=910 and 777, on 777, $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle.

Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia County Highway 617=910, 0.15 miles north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—Large size, beaded costellae, and poorly differentiated costellae are features of this species. The shell is not so robust as *S. curdsvillensis* nor are its interiors as much thickened as those of the Kentucky species. *Sowerbyella eximia* does not attain as large a size as *S. punctostriata* (Mathers), and its cos-

tellae are not arranged in groups of several fine ones alternating with coarser ones as in the Wolfe Island species.

SOWERBYELLA INDISTINCTA Cooper, new species

Plate 202, D, figures 24-26

The specimens on which this species is based are smaller than *Sowerbyella compacta* from the Benbolt formation in Virginia and Tennessee and have nearly the same shape but differ in ornamentation and size. These two species are very close, but despite their similarity constant differences between the two occur that are sufficient to distinguish them. In external form the Oklahoma shell has more oblique or sloping lateral margins and somewhat more acute cardinal extremities. The Appalachian species attains a greater size. The contours of the two species differ slightly, the Oklahoma form having in general a somewhat more concave brachial valve. In ornamentation the eastern species has less numerous costellae, about 120 as compared with about 140 in the Oklahoma form. Furthermore, no crescentic spines were observed on the latter, although concentric fila are easy to see.

Inside the valves the Oklahoma shell seems to be less thickened in both valves when compared with specimens of similar size from the Appalachians. The brachial valve of *S. compacta* has a much wider and more greatly thickened periphery.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype (pedicle valve) | 6.7 | ? | 9.4 | 11.4 | ? |
| Paratype (" " 117493b).... | 7.3 | ? | 10.1 | 10.4 | ? |
| " (" " 117493a")... | 6.9 | ? | 10.0 | 11.7 | ? |
| " (" " 117493a'") .. | 7.9 | ? | 10.9 | 11.0 | ? |
| " (brachial valve 117493c)... | ? | 6.7 | 10.3 | 12.0 | ? |
| " (" " 117493a') .. | ? | 6.4 | 9.8 | ? | ? |

Types.—Holotype: 117493a; figured paratypes: 117493b,c, unfigured paratypes: 117493a', a'', a'''.

Horizon and locality.—Bromide formation (Mountain Lake member) in Carter County, Okla.: About the middle of sec. 33, T. 2 S., R. 2 E., 2 miles north-east of Springer; SE $\frac{1}{4}$ sec. 32, T. 2 S., R. 2 E., 3 miles north-northeast of Springer.

SOWERBYELLA LEBANONENSIS Bassler

Plate 201, B, figures 14-25

Sowerbyella lebanonensis BASSLER, Tennessee Div. Geol., Bull. 38, p. 192, pl. 5, figs. 7, 8, 1932 (nomen nudum); Journ. Washington Acad. Sci., vol. 25, No. 9, p. 406, 1935.

About medium size for the genus, wider than long with the length slightly less than two-thirds the width. Outline subrectangular; lateral margins nearly straight, sloping gently toward the middle; anterior margin very broadly rounded to truncate or, in some specimens, slightly emarginate. Cardinal extremities

forming an acute angle, produced slightly into small points or ears. Surface marked by costellae of unequal size, the larger ones separated by 1 to 5 of the finer ones. In addition to the radial markings the surface is covered by very fine concentric fila and up to 7 short, oblique wrinkles along the posterior margins on each side of the hinge.

Pedicle valve with moderate curvature in lateral profile and forming a broad, gentle arch in anterior profile. The beak is inconspicuous and only very slightly produced beyond the posterior margin. Umbo low and broad, not easily distinguished from body of shell. Midregion and flanks somewhat swollen; slopes to cardinal extremities steep. Anterior slope steep. Interarea not much longer than that of the brachial valve, short, apsacline. Pseudodeltidium nearly obsolete.

Brachial valve moderately concave with the concavity greatest at about the middle; flanks gently concave and anterolateral areas somewhat flattened. Cardinal extremities very slightly deflected. Interarea hypercline, nearly as long as the interarea of the pedicle valve.

Interior: Pedicle valve with delthyrial cavity wide, partially filled by callus deposit; median ridge very thin in the young, well thickened in the adult, extending about one-third the length of the valve. Ridges bounding outside margin of diductor-adjustor field short and stout; diductor-adjustor field wide and long extending to the middle of the valve. Shell thickened and papillose just inside the anterolateral margins.

Brachial valve interior with median ridge and lateral septa low; shell not greatly thickened in the young but strongly thickened in old shells forming a strong subperipheral border on the sides and toward the front and a steep anterior slope. In old shells medium septum becoming obsolete and lateral septa greatly thickened.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|-------|-------------|-----------|--------|
| Lectotype | 7.3 | ? | 11.5 | 12.4 | ? | 1.5 ? |
| Hypotype (117497a)... | 6.8 | ? | 10.1 | 11.2 | ? | ? |
| " (117497b)... | ? | 7.9 | 12.1 | 13.2 | ? | ? |
| " (117497c)... | ? | 7.9 | 12.7 | 12.2 | ? | ? |
| " (117494a)... | 9.1 | 8.2 | 14.4 | 15.3 | 2.2 | 3.2 |

Types.—Lectotype: 80487a, paratypes: 80487b-d; figured hypotypes: 117494a-c, 117495a, 117496a, 117497c; measured hypotypes: 117497a,b.

Horizon and locality.—Lebanon formation in Tennessee: At Shelbyville, Bedford County; Columbia, Maury County; near Prospect, Giles County; near Bradyville, Cannon County; LaVergne, Rutherford County. Cut on U. S. Highway 241, 2.1 miles north of Bedford County line; U. S. Highway 70S, 1½ miles east of Brinkley School, east of Murfreesboro; near Readyville; U. S. Highway 70S, 1.65 miles west of Cripple Creek, 1.5 miles west of Kittrell; Rutherford County. On Tennessee Highway 16, 1 mile south of Rutherford County line.

Discussion.—This species occurs in great abundance in the lower part of the

Lebanon limestone of the central basin of Tennessee. It is characterized by its transversely subrectangular outline, the well-differentiated costellae, and the moderately thickened interiors.

This species name first appeared in Dr. Bassler's description of the Stratigraphy of the Central Basin of Tennessee. In that publication the name proved to be a nomen nudum because the illustrations were unaccompanied by a description. Three years later a short characterization was published, but this failed to indicate a type specimen. In the original publication two specimens were figured, and these were again referred to in the later characterization. These two specimens are thus the cotypes. It seems best here to select the pedicle valve (fig. 8) U.S.N.M. 80487a. This is a most unfortunate specimen to represent the species because it is crushed and has an unusual development of wrinkles on the posterior margin. It is better, however, than the other alternative which is a brachial interior.

Bassler's characterization stressed the ornamentation and the fact that the septa of the brachial valve almost meet the anterior margin. This seems to be true in a few specimens, but generally the brachial plates terminate in a crest near the valve middle as they do in all other species.

Sowerbyella lebanonensis, because of its considerable width, should not easily be confused with other *Sowerbyellas* described in this report. It is in that respect unlike *S. compacta* and *S. socialis*, which might be confused with it. The latter, moreover, is much more coarsely ornamented, and in the former the costellae are not arranged in sectors of fine and large ones as in *S. lebanonensis*.

SOWERBYELLA MEDIOPLICATA Cooper, new species

Plate 204, A, figures 1-5

Small, semielliptical in outline; hinge forming the widest part, auriculate; sides oblique; anterior margin broadly rounded; costellae subequal, about 4 to the millimeter at the front margin.

Pedicle valve moderately convex in lateral profile with the maximum convexity at about the middle; anterior profile broadly convex with the median region narrowly humped and the flanks depressed below it; lateral slopes moderately steep. Umbonal and median regions narrowly swollen to form a marked median fold which forms a wave in the commissure; flanks moderately swollen.

Brachial valve with a prominent median sulcus extending from umbo to anterior margin; flanks fairly deeply concave but posterolateral extremities somewhat flattened. Interior with slender median plates; anteromedian region moderately thickened.

Measurements in mm.—Holotype, length 4.8, brachial length 4.3, midwidth 7.4, hinge width 8.7, thickness 1.3, height 1.8.

Types.—Holotype: 117498.

Horizon and locality.—Upper Lincolnshire formation in Virginia: Along Tumbling Run, 1½ miles southwest of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species is characterized by small size, fairly strong but

poorly differentiated costellae, and the presence of a strong plica or fold on the pedicle valve. This species is smaller than *S. silicica* which is not so strongly folded. It is suggestive of *S. varicostellata* but is also smaller than that species, more strongly concave, more strongly folded in the median part of the pedicle valve, and has stronger costellae.

SOWERBYELLA MERRIAMII Cooper, new species

Plate 269, D, figures 18-22

Shell of about medium size for the genus, wider than long and with the hinge forming the greatest width; sides slightly rounded, sloping medially; anterior margin strongly rounded; anterior commissure rectimarginate. Surface costellate, costellae of unequal size, 7 to 9 of the strongest ones in 5 mm. at the front margin, each of the stronger costellae separating 1 to 5 of the finer ones. Posterior margins with numerous irregular, oblique wrinkles.

Pedicle valve gently convex in lateral profile, with the greatest convexity in the posterior third and with the anterior two-thirds flattened. Anterior profile subcarinate. Umbo narrowly swollen; umbonal slopes short and gentle, melting into the flattened flanks and medial portion. Interarea strongly apsacline and moderately long. Pseudodeltidium small.

Brachial valve nearly flat except in the umbonal region which is deeply concave, the concavity extending along the posterior margin and dying out on the flanks and median region, lateral and anterior regions nearly flat.

Interior unknown.

Measurements in mm.—Holotype, length 11.6, length of brachial valve 11.0, midwidth 17.3, hinge width 18.9, thickness 2.1.

Types.—Holotype: 124234a; unfigured paratypes: 124234b-d.

Horizon and locality.—Dark shale under the Eureka quartzite in Nevada: Under two knobs of Eureka quartzite, north side of canyon, 3.1 miles N. 32° E. of the Blair (Segura) Ranch, Antelope Mountains, Roberts Mountains (1°) Quadrangle.

Discussion.—This species can be recognized by its fairly large size, wide hinge, strong ornamentation, and flattened form. It is suggestive of *S. eximia* from contemporaneous rocks in Virginia but is more strongly ornamented and flatter in profile. *Sowerbyella monilifera* resembles the Nevada species but is usually smaller, less extended along the hinge, and has finer ornamentation.

SOWERBYELLA MONILIFERA Cooper, new species

Plate 199, A, figures 1-8; plate 206, E, figures 16-28

Shell large, subrectangular to subelliptical in outline, wider than long, with the length about two-thirds the width; cardinal extremities angular to auriculate. Sides gently rounded, moderately oblique; anterior margin broadly rounded; costellae of several sizes but with a prominent strong set in a field of fine ones; 8 of the stronger costellae occupy 5 mm. at the front margin; larger costellae separated by 1 to 6 of the fine costellae, which are beaded.

Pedicle valve unevenly convex in lateral profile with the maximum convexity just anterior to the umbo; anterior profile with the median region narrowly elevated to form a moderately elevated hump with the sides concave and descending moderately to the margins; beak small; umbo somewhat narrowly swollen and passing into the moderately inflated median region; umbonal slopes to posterior margin short and moderately steep. Anterior slope long and gentle; posterior slope short and steep. Interarea moderately long, strongly apsacline; pseudo-deltidium small.

Brachial valve most concave just anterior to the umbo which is also concave; lateral areas gently concave and posterolateral extremities somewhat flattened.

Pedicle interior with elongate diductor scars diverging at an angle of about 55° ; median ridge low, anterior forks of median ridge low; pallial trunks not strongly developed. Brachial valve with median ridges low and closely spaced; adductor callosity elongate, narrowly oval; marginal thickening not strong.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 9.6 | 9.2 | 15.2 | 16.9 | 1.8 | 2.5 |
| Paratype (117499a) .. | 9.1 | 8.7 | 13.2 | 15.1 | 1.7 | 2.2 |
| " (117500a) .. | 11.9 | 11.2 | 17.0 | 19.4 | ? | ? |
| " (117500c) .. | 9.8 | 9.5 | 13.5 | 15.5 | 2.1 | 2.6 |
| " (117500d) .. | 11.4 | 11.0 | 15.5 | 16.1 ? | 2.3 | 3.2 |
| " (117500e) .. | 9.2 | 8.9 | 14.1 | 16.2 | 1.9 | 2.8 |
| " (117500f) .. | 9.6 | 9.0 | 15.1 | 16.5 | 1.3 | 2.3 |
| " (117500i) .. | ? | 8.8 | 13.8 | 14.8 | ? | ? |
| " (117500-l) .. | ? | 8.9 | 12.0 | 12.3 | ? | ? |
| " (117500m) .. | 11.2 | 10.5 | 16.6 | 17.6 | 2.8 | 3.6 |

Types.—Holotype: 117500b; figured paratypes: 117499a,b, 117500a,c,g,i; unfigured paratypes: 117500d-f,h,j-m.

Horizon and locality.—Decorah formation (Ion member) in Goodhue County, Minn.: about 1 mile east of U. S. Highway 52, on the south side of Cannon Falls; Wagner Hill, on U. S. Highway 52, 5 miles south of Cannon Falls; Kenyon; Minneapolis; and in Fillmore County: On U. S. Highway 52, 1 mile south of Fountain.

Same formation in Iowa: Along the Dugway, $\frac{1}{2}$ mile west of Decorah, Winnebago County.

Same formation in Wisconsin: From a cut on Wisconsin Highway 10, $\frac{1}{4}$ mile west of Ellsworth, Lancaster (30') Quadrangle.

Discussion.—Its large size and its well-differentiated and strongly beaded costellae make this species comparable with *S. punctostriata* and similar species. The Minnesota species differs from *S. punctostriata* in its lesser width and more compact form. It is a much less robust form than *S. curdsvillensis*, and its interiors are not so strongly thickened. *Sowerbyella eximia* is somewhat differently proportioned and has a completely different ornamentation.

SOWERBYELLA NASUTA Cooper, new species

Plate 199, C, figures 18-34; plate 215, A, figures 1-4

Shell small, subquadrate, wider than long; sides nearly straight; cardinal extremities nearly a right angle; ears small; anterior margin subnasute. Finely costellate, with about 5 or 6 costellae in 1 mm. at the front margin.

Pedicle valve fairly strongly and evenly convex in lateral profile with the median region being the most convex part; anterior profile broadly convex; umbonal region narrowly convex, often subcarinate medianly, the convexity continued to the front margin as a moderately strong, narrow median fold; flanks gently inflated, depressed somewhat below the median fold and with moderately steep slopes to the margins. Interarea moderately long, strongly apsacline. Interior with short, rounded, deeply impressed diductor scars with strong, branched pallial sinuses diverging from their anterior ends. Median ridge low.

Brachial valve gently concave and marked by a distinct narrow, shallow sulcus extending from beak to anterior margin; flanks bounding sulcus gently concave to flattened; posterolateral extremities flattened. Interior with 2 closely spaced septa strongly elevated near the middle of the valve; slope anterior to anterior ends of septa steep, strongly papillose. Sides depressed, papillose, and moderately thickened inside the margin.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 8.1 | 7.4 | 9.9 | 10.1 | 2.3 | 2.9 |
| Paratype (117503a) | 7.0 | 6.2 | 8.9 | 9.2 | 2.1 | 2.5 |
| “ (117503c) | 7.0 | 6.3 | 9.0 | 9.5 | 2.1 | 2.8 |
| “ (117502a) | 6.4 | 5.9 | 8.3 | 9.7 | 1.9 | 2.3 |

Types.—Holotype: 117503b; figured paratypes: 117502a-c, 117503a,c-h; figured specimen: 117501.

Horizon and locality.—Chatham Hill formation in Virginia: On the north slope of Walker Mountain, 2 miles south-southwest of Chatham Hill, Chatham Hill (T.V.A. 218-NE) Quadrangle.

Ward Cove formation (*Nidulites* bed) in Virginia: Thompson Valley, southwest of Tazewell, Pounding Mill (15') Quadrangle.

Ward Cove formation (just above *Nidulites*) in Virginia: North of U. S. Highway 19, $\frac{1}{4}$ mile west of Pounding Mill, Pounding Mill (15') Quadrangle.

Discussion.—This little species is characterized by the prominent median fold on the pedicle valve. This fold is narrow and extends from the beak to the anterior margin and may cause the margin to become nasute. A number of species have developed a median fold similar to this one, but it is not so marked in any other species as in this one and *S. subcarinata*. *Sowerbyella nasuta* differs from *S. carinata* in size and proportions, the former being more quadrate and having a length/width index of about 0.78 whereas that of *S. subcarinata* averages about 0.70.

SOWERBYELLA NEGRITUS (Willard)

Plate 197, A, figures 1-10

Plectambonites negritus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 278, pl. 3, fig. 13, 1928.

Sowerbyella sp. BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 72, pl. 81, figs. 21, 22, 1942.

Shell of about medium size for the genus, wider than long with the length about two-thirds the width; hinge forming the greatest width and about twice the length. Lateral margins slightly curved; anterior margin broadly rounded. Surface marked by costellae of unequal size. Five to seven of the stronger costellae may be counted on each side of a still stronger median costella. The stronger costellae define low plications that wrinkle the front margin. Between the stronger costellae 2 to 8 of the finer radii occur. About 13 costellae may be counted in 2 mm. at the front of a large valve. In addition to the costellae 4 oblique wrinkles are present along the hinge on each side of the beak.

Pedicle valve evenly and moderately convex in lateral profile and with the most convex part of the shell at the middle. Anterior profile with sides rising gradually to the highest part in the middle of the valve which is humped into a low fold. Beak inconspicuous and only slightly produced posterior to the posterior margin. Beak and umbo produced into a low fold broadening anteriorly to occupy about one-quarter of the width. Region about cardinal extremities flattened, rising gradually to the base of the fold. Sides of fold moderately steep. Interarea short, nearly flat, apsacline.

Brachial valve strongly concave with the greatest concavity in the median region. Sulcus narrow and extending to the anterior margin where it indents the commissure toward the pedicle valve. Concavity decreasing laterally. Cardinal extremities sulcate, deflected toward the pedicle valve. Anterolateral areas not strongly incurved.

Interiors: Not known in detail. Structures of brachial valve appear to be characteristic of *Sowerbyella*.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Hypotype (117504a)... | 6.1 | 5.3 | 9.7 | 11.9 | 1.3 | 1.8 |
| " (117504c)... | 5.8 | ? | 8.8 | 10.8 | ? | 2.0 ? |
| " (117506a)... | 7.8 | ? | 13.0 | 15.0 | ? | ? |

Types.—Holotype: M.C.Z. 8615; figured hypotypes: 117504a,c, 117505d, 117506a,b.

Horizon and locality.—Botetourt formation in Virginia: At junction of Virginia Highways 311 and 114, $\frac{1}{2}$ mile southwest of Catawba, 11 miles north of Salem, Salem (15') Quadrangle; $1\frac{1}{2}$ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle; on Virginia Highway 114, 2.3 miles west of Montgomery-Roanoke County line, 12 miles northeast of Blacksburg.

Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle.

Ward Cove formation in Virginia: 0.4 mile northeast of Jeff Gillespie's, Thompson Valley, west-southwest of Tazewell, Pounding Mill (15') Quadrangle.

Lower Chatham Hill formation in Virginia: On the Grayson Farm, 4 miles southwest of Bland; 6 miles southwest of Bland; Bland County.

Whitesburg formation in Tennessee: 1½ miles northeast of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Discussion.—*Sowerbyella negritus* is best characterized by its ornamentation, the depth of its valves, and the pointed cardinal extremities. The ornamentation consists of strong costellae separated by 2 to 8 finer costellae, the higher numbers of finer costellae predominating. The shell is also well wrinkled along the posterior margin. In addition to these features a crude, obscure plication appears in some of the shells, particularly the median part of the pedicle valve which is often strongly folded.

Few species have been described that can be compared to this one. It is close to *S. perplexa*, but that species is generally more convex, does not have a prominent median fold, and the strong costellae are separated by a smaller number of the fine radii.

SOWERBYELLA PARVA Cooper, new species

Plate 202, B, figures 9-15

Shell small for the genus, wider than long, semielliptical in outline; sides nearly straight to gently convex; anterior margin rounded; widest near the middle in the adult; cardinal extremities nearly a right angle, rarely auriculate; finely costellate, costellae fairly even in size but somewhat differentiated into larger and smaller ones at the front margin: 6 to 7 costellae in 1 mm. at the front margin.

Pedicle valve moderately convex in lateral profile; anterior profile rising to a low crest medially and with long, flat, moderately dipping slopes. Umbo narrowly swollen; median fold absent or obscure; flanks gently inflated; interarea strongly apsacline.

Brachial valve with a poorly defined concave sulcus extending from the concave umbo to the front margin; center of valve most deeply concave part; flanks gently concave, lateral and posterolateral regions flattened.

Pedicle interior with short but strong median septum dividing subflabellate diductor fields; pallial trunks moderately developed. Brachial valve moderately thickened; septa moderately elevated at the middle of the valve; anterior slope not strongly thickened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 6.5 | 6.1 | 9.0 | 8.7 | 1.4 | 1.9 |
| Paratype (117507b) ... | 7.0 | 6.6 | 9.4 | 8.9 | 1.7 | 2.2 |

Types.—Holotype: 117507a; figured paratypes: 117507b-d.

Horizon and locality.—Ward Cove formation in Virginia: In small cemetery

about $\frac{3}{8}$ mile north of Rye Cove; 1 mile northwest of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species is small and marked by fine costellae; it resembles *S. compacta* in form but is never so large, and is not so deep as the Benbolt species. *Sowerbyella indistincta* is like this species in size, but it has acute cardinal extremities in the adult whereas in *S. parva* the cardinal extremities are obtuse. Furthermore, the brachial valve of the Ward Cove species is more shallow than that of the Oklahoma species.

SOWERBYELLA PERPLEXA Cooper, new species

Plate 196, F, figures 30-44

Shell of about medium size for the genus; semielliptical in outline; wider than long with the hinge forming the widest part; cardinal extremities auriculate; sides oblique; anterior margin broadly rounded; 2 large costellae in 1 mm. at the front margin; 3 to 5 fine costellae between the larger ones. Obscure oblique wrinkles on the posterior margins.

Pedicle valve fairly evenly and moderately convex in lateral profile; anterior profile with median region rounded, not strongly elevated and with long gentle slopes. Valve swollen in the middle; umbo moderately inflated.

Brachial valve most strongly concave just anterior to the umbo; concavity lessening anteriorly and laterally; posterolateral regions gently concave.

Pedicle interior with narrow, deep, widely divergent diductor scars; median ridge short; brachial interior with delicate septa and often having the median septum unusually well developed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 6.2 | 5.4 | 9.7 | 11.0 | 1.3 | 2.2 |
| Paratype (117508c)... | 5.2 | 4.7 | 7.8 | 9.1 | 1.0 | 1.6 |
| " (117508k)... | 6.1 | 5.6 | 8.4 | 9.7 | 1.3 | 1.2 |
| " (117508f)... | ? | 8.0 | 12.5 | 12.5 | ? | ? |

Types.—Holotype: 117509a; figured paratypes: 117508b-g,i; unfigured paratypes: 117508a,h,j-l, 117509b.

Horizon and locality.—Chatham Hill formation in Virginia: On north slope Walker Mountain, 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—*Sowerbyella perplexa* has its fine costellae blocked out in definite bands by strong costellae, and the brachial valve is fairly deep. The species is most like *S. negritus* but differs in not having the costellae arranged in as broad bands as those of *S. negritus* and in not having a narrowly convex median region on the pedicle valve and a somewhat sulcate brachial valve. The Chatham Hill species also lacks the strong suggestion of plication on the pedicle valve of *S. negritus*.

SOWERBYELLA PLICATIFERA Cooper, new species

Plate 203, A, figures 1-15

Shell of about the usual size for the genus, wider than long and with the width at the hinge nearly twice the length. Cardinal extremities acute to mucronate. Lateral margins oblique and straight to oblique and somewhat rounded. Anterior margin broadly rounded to nasute. Anterior commissure often wrinkled by 3 more or less strong plications, 1 on the pedicle valve and 2 on the brachial valve. Surface multicostellate; costellae crowded, narrowly rounded, with interspaces narrower to slightly wider than the width of the costellae, varying from nearly equal in size to well differentiated in size with as many as 3 fine costellae separating the larger ones, about 120 to 160 in number. At the front margin 5 to 7 costellae occupy a space of 1 mm. Interspaces occupied by fine, elevated concentric fila. Costellae ornamented by small crescent-shaped spines, about 6 to the millimeter, giving them a beaded effect.

Pedicle valve forming a low arch in anterior profile with a narrowly rounded crest and sides sloping gently to the margins. In lateral profile the curvature is moderate and the greatest curvature is slightly posterior to the middle. Beak inconspicuous; umbo narrowly elevated and extended forward to the front margin as a low narrow fold outlined by a shallow depression on each side. Flanks narrowly but often obscurely folded by a low plica that meets the front margin at the anterolateral extremities. Slopes to cardinal extremities concave but gentle. Interarea short, slightly curved and apsacline in position.

Brachial valve with most concave portion near the middle and with the concavity extending to the front margin as a narrow sulcus. Sulcus bounded by low, narrowly rounded plications that extend to about the middle of the valve. Outside each plica a shallow sulcus may occur, but often, especially in younger specimens, the shell is gently concave to the cardinal extremities where it is somewhat flattened. Cardinal extremities slightly deflected toward the pedicle valve. Interarea short, hypercline.

Interior: Not known beyond the fact that the brachial valve possesses typical *Sowerbyella* septa.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|-------|-------------|-----------|--------|
| Holotype | 8.9 | 8.2 | 13.6 | 15.0 | 1.8 | 2.8 |
| Paratype (117512a) .. | 8.6 | 8.0 | 12.5 | 12.9 | 1.4 | 2.6 |
| “ (117511a) .. | 7.8 | 7.4 | 12.0 | 14.5 | 1.7 | 2.6 |
| “ (117511b) .. | 7.8 | 7.6 | 11.9 | 13.8 | 1.5 | 2.3 |

Types.—Holotype: 117512b; figured paratypes: 117511a, 117512a; unfigured paratypes: 117510, 117511b,c.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: West of Nebo, Murray County; NW $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., $\frac{1}{4}$ mile west of U. S. Highway 77, Carter County.

Discussion.—This species is characterized by strongly beaded costellae, deep brachial valve, acute cardinal extremities, and the presence of fairly strong folds,

the median one always present but others on the flanks usually visible. *Sowerbyella plicatifera* is most like *S. socialis* and *S. variabilis*. It differs from the first in not being so robust, in being deeper, particularly along the posterior margin of the brachial valve, in being more finely costellate, and in having more prominent plicae. *Sowerbyella plicatifera* differs from *S. variabilis* in its stronger costellae, the prominent folding of the pedicle valve, and the less deep brachial valve.

SOWERBYELLA PUNCTOSTRIATA (Mather)

Plate 205, C, figures 9-25; plate 206, D, figures 14, 15

Plectambonites punctostriatus MATHER, Ottawa Nat., vol. 31, p. 38, pl. 1, figs. 15-17, 1917.

This species is widely identified in the lower part of the Trenton, particularly in New York and Ontario. The species is characterized by its large size and beaded ornamentation which gives the appearance of a pitted or punctate surface. It is most like *S. curdsvillensis* Foerste which is widely distributed in the Southern Appalachians and parts of the upper Mississippi Valley. *Sowerbyella punctostriata* is distinguished from *S. curdsvillensis* as follows: 1, lesser convexity and generally thinner valves; 2, less deeply concave brachial valve; 3, greater development of the oblique wrinkles along the posterior margins; 4, fairly late development of thickened subperipheral ridge in old adults; 5, lesser thickening of all internal structures; 6, greater tendency to auriculate cardinal extremities.

Specimens in the National Museum indicate that this species is variable. Perhaps when its stratigraphic range has been more accurately worked out, some splits may be made from it. As indicated by topotypes the species is fairly thin shelled, only moderately convex, and the interior is scarcely thickened to a notable degree. The amount of thickening of the internal structures and the development of a subperipheral rim were given by Mather as points of distinction between *S. punctostriata* and *S. curdsvillensis*. Specimens referable to the former species have been seen which have a prominent subperipheral rim and pronounced internal features. On the other hand, specimens referable to the Kentucky species occur which do not have the strongly emphasized interiors. The degree of development of these features may be a matter of environment, the quiet-water limestone specimens having the delicate shell while the dwellers of sandy bottoms of the basal Martinsburg in the Southern Appalachians with its more turbulent water having the stronger shells. It is further possible that large suites of specimens will indicate that *S. punctostriata* and *S. curdsvillensis* are actually one species.

Types.—Figured hypotypes: 117513a,b, 117514a,b, 117515a,b; figured topotype: 117516.

Horizon and locality.—Rockland formation in New York and Ontario: Wolfe Island, Lake Ontario.

Decorah formation (Guttenberg member) in Wisconsin, Iowa, Minnesota, and Missouri.

Barnhart formation in Missouri: Koch Valley School, on U. S. Highway 61, NE. corner SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T. 41 N., R. 6 E., 2 miles south of Barnhart,

Kimmswick (15') Quadrangle; old road 1 mile northwest of Chicago Summer School Camp, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 37 N., R. 9 E., Weingarten (15') Quadrangle.

SOWERBYELLA SILICICA Cooper, new species

Plate 196, D, figures 20-26

Sowerbyella sp. BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 42, pl. 73, figs. 40, 41, 1942.

Width of shell at hinge slightly less than twice the length; cardinal extremities acute, drawn into small ears; lateral extremities indented just anterior to the ears; anterolateral margin moderately rounded; anterior margin broadly rounded. surface marked by costellae of unequal size; about 20 to 30 of the larger ones are separated by 2 to 4 of the smaller costellae. The median stronger costella of the pedicle valve is often the strongest and most prominent of all.

Pedicle valve gently convex in lateral profile; unevenly convex in anterior profile with the median region elevated and the lateral areas or flanks descending gently to the lateral margins. Beak low, inconspicuous, protruding only slightly posterior to the posterior margin. Umbo narrowly elevated and extending anteriorly into the narrow median fold. In the anterior portion of the valve and on each side of the fold short sulci often exaggerate the height of the fold. Flanks nearly flat or very gently convex in profile. Interarea slightly curved, nearly orthocline to gently anacline in position.

Brachial valve generally moderately to deeply concave, with the greatest concavity slightly anterior to the middle. Umbo concave; sulcus widening from the umbo to the front margin where it is about one-fourth the width at the hinge. Width of sulcus dependent on production of feeble to moderately strong plicae on each side; the stronger the lateral plicae the narrower the fold. Flanks bounding fold nearly flat to moderately concave. Brachial ears faintly concave to flat. Interarea strongly hypercline.

Interior: Pseudodeltidium reduced; median adductor ridge strong, equal in length to about one-fourth the length of the valve; ridges bounding anterior margin of diductor scars diverging at an angle slightly less than a right angle.

Brachial valve with lateral septa most elevated at a point slightly anterior to the middle; median septum nearly obsolete. Muscle area slightly thickened and most elevated at the point where the septa end.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 6.1 | 5.6 | 8.8 | 11.0 | 1.3 | 2.2 |
| Paratype (117517b)... | 6.8 | 6.1 | 9.5 | 11.0 ? | 1.4 | 2.1 |
| " (98213d).... | 4.9 | 4.7 | 7.0 | 7.3 | 1.0 | 1.3 |

Types.—Holotype: 117517a; figured paratype: 117517b; unfigured paratypes: 98213a-c, 123457; measured paratype: 98213d.

Horizon and locality.—From the upper part of the Arline formation in Virginia: At entrance to Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This is a small species characterized by costellae prominently grouped into strong ones alternating with groups of finer ones. In this respect it is like *S. negritus* but never attains the large size of that species. It is also

not so strongly alate, and the bands of fine costellae are much narrower. The species is suggestive of *S. varicostellata* but is a larger species.

SOWERBYELLA SILICICA NANA Cooper, new subspecies

Plate 196, C, figures 15-19

Sowerbyella sp. BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 42, pl. 73, fig. 38, 1942.

Shell small, wider than long with the width about one-third greater than the length; hinge forming widest portion; cardinal extremities forming an acute angle; slightly auriculate. Lateral margins slightly indented just anterior to the cardinal extremity and nearly straight or slightly curved before joining the narrowly rounded anterior margin. In old specimens the anterior commissure is sulcate and the anterior margin may be slightly produced by the sulcus. Surface marked by costellae of unequal size, about 28 of the larger costellae separated by 2 to 4 of the finer ones.

Pedicle valve having a gently convex lateral profile but with the anterior profile strongly arched at the middle and with sides flattened. Beak low, inconspicuous, scarcely protruding posterior to the posterior margin. Umbonal region narrowly swollen and produced forward to join with a conspicuous, rounded, but low fold. Lateral slopes flattened, moderately steep. On each side of the fold a low plica is often visible on the lateral slope and extending to the anterolateral extremity. Interarea nearly flat, moderately to strongly apsacline. Pseudodeltidium short, narrow.

Brachial valve unevenly concave with the greatest concavity located along the median line where the valve is deeply sulcate. Umbo concave. Flanks of shell bounding sulcus only moderately concave and with 2 indefinite but perceptible plicae corresponding to the depressed areas of the ventral flanks bounding the fold. Interarea anacline.

Interior: Nothing known beyond the presence of the 2 diverging septa.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 6.4 | 6.1 | 8.2 | 8.0 | 1.4 | 2.1 |
| Paratype (117518a)..... | 6.6 | 5.9 | 8.3 | 9.4 | 1.8 | 2.3 |
| " (117518b)..... | 6.7 | 5.9 | 8.4 | 9.0 | 1.4 | 2.6 |
| " (117518c)..... | 6.2 | 5.3 | 8.6 | 8.7 ? | 1.7 | 2.2 |

Types.—Holotype: 98229a; unfigured paratypes: 98229b, 117518a-c.

Horizon and locality.—Arline formation in Virginia: At entrance to Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This subspecies differs from *S. silicica* in its somewhat smaller size and in the nearly rectangular cardinal extremities.

SOWERBYELLA SOCIALIS Cooper, new species

Plate 198, B, figures 23-44; plate 205, A, figures 1-6

Sowerbyella sp. BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 93, pl. 90, figs. 1-16, 1942.

Shell semielliptical, length about two-thirds the width at the middle; hinge forming widest part; cardinal extremities acute, often drawn out into small ears;

lateral margins generally straight in outline and sloping moderately toward the middle. Anterior margin usually broadly rounded, occasionally slightly nasute when the fold is well developed. Posterior margin nearly straight. Surface multicostellate; costellae appearing in 3 generations. Second and first generation costellae of about same size at front of valve; 1 to 2 of the finer costellae of the second and third generation alternate with the coarser ones. At the front margin of a fully adult valve about 120 to 130 costellae of all sizes may be counted, about 5 in 1 mm. at the front margin near the center. Between the costellae the shell is marked by fine, crowded concentric fila; in very well preserved specimens the costellae bear short imbricating spines. A few wrinkles along the posterior margin occasionally seen.

Pedicle valve moderately but unevenly convex in lateral profile; anterior profile with the greatest convexity in the middle but not greatly elevated and with the flanks sloping gently to the margins. Beak inconspicuous, protruding very slightly beyond the posterior margin. Umbo narrow, slightly swollen, extended forward as a low and narrow fold nearly to the front margin. Flanks bounding fold full in anterolateral regions; slopes to cardinal extremities moderate. A tendency to form an obscure plication along the middle of each flank has been observed. Interarea curved, strongly apsacline. Pseudodeltidium much reduced.

Brachial valve with moderately concave umbo and with concavity extended forward as a narrow sulcus to the anterior margin or disappearing slightly before the margin. Flanks bounding sulcus moderately concave or nearly flat. Cardinal extremities flattened and deflected slightly toward the pedicle valve. Chlidium deeply cleft to form chlidial plates. Interarea hypercline.

Interior of pedicle valve with small teeth but strongly reenforced fossettes; dental plates obscured by secondary deposits; apex of delthyrial chamber filled by callus deposit into which the adductor impressions are deeply sunk. Adjustor-diductor fields not widely divergent, subflabellate. Median ridge low and slender, extending about one-third the length. Pallial marks well impressed. Anterior and anterolateral portions strongly thickened and papillose. Brachial valve usually without a greatly thickened periphery; median ridge low and inconspicuous; lateral ridges low, strongly elevated anteriorly; muscular areas not greatly thickened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 8.1 | 7.0 | 11.9 | 14.3 | 1.9 | 2.6 |
| Paratype (117525c)... | 9.1 | 8.4 | 12.8 | 15.2 | 2.3 | 3.0 |
| " (117523a)... | 7.8 | 7.1 | 11.9 | 14.0 | 1.8 | 2.3 |
| " (117521).... | 7.9 | 7.2 | 11.0 | 12.4 | 2.1 | 2.7 |
| " (117530a)... | 9.0 | 8.6 | 12.6 | 13.6 | 1.9 | 2.3 |
| " (117530b)... | 7.9 | 7.4 | 11.2 | 13.5 | 1.1 | 1.7 |
| " (117526a)... | 8.9 | 8.4 | 13.2 | 14.4 | 1.9 | 2.6 |
| " (98206b).... | 10.2 | 9.6 | 15.0 | 18.4 | 2.0 | 3.0 |

Types.—Holotype: 117525a; figured paratypes: 98206a-d (Butts), 98207b, 117522, 117523a, 117524a, 117525b, 117526a,b, 117527a,c, 117530a,b; unfigured

paratypes: 98206a-d, 98027a,c-e, 117519a,b, 117520a,b, 117521, 117523b, 117524b, 117525c, 117527b.

Horizon and locality.—Wardell formation and Wardell part of Dryden formation in Clinchport (T.V.A. 188-NW) Quadrangle, Virginia: At Lloyd Carter's barn, 0.8 mile northeast of the new school at Rye Cove; several other localities in the vicinity of Rye Cove; Mannville School.

Wardell formation (*Hesperorthis* zone) in Tennessee: On U. S. Highway 25E, Evans Ferry section, 0.8 mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—*Sowerbyella socialis* occurs in great numbers in several localities. It is characterized by strongly beaded costellae, acute cardinal extremities, fairly strong costellae not differentiated into well-marked zones. The species is most like *S. compacta*, and the interiors of the two species are nearly identical. It differs from *S. compacta* in attaining a somewhat larger size and in having stronger costellae and stronger beading on their surface. This species is also suggestive of *S. variabilis* but has a thicker shell and more robust form. It is also much more strongly costellate. *Sowerbyella socialis* differs from *S. perplexa*, which it resembles in form and size, in not having its costellae well differentiated into zones and in having strong beading not possessed by the Chatham Hill species. *Sowerbyella socialis* should not be confused with *S. lebanonensis* because that is a shorter form and also has its costellae differentiated into zones.

SOWERBYELLA SOCIALIS CRASSA Cooper, new subspecies

Plate 200, B, figures 7-14

Shell of about medium size for the genus, wider than long, and with the length equal to about three-fifths the width at the hinge. Cardinal extremities acute, often drawn into small ears. Lateral margins indented just anterior to the cardinal extremity, otherwise straight and oblique; anterior margin broadly rounded, occasionally subnasute. Surface marked by costellae of unequal size, from 70 to 90 on a valve. First and second generations of costellae narrowly rounded and high. In 1 mm. at the front of an adult of average size 3 large costellae may be counted. Between the larger costellae 1 or 2 smaller ones of a third generation may or may not be intercalated. Costellae strongly spinose.

Pedicle valve moderately convex in lateral profile and forming low swelling highest in the middle in anterior profile. Beak inconspicuous; umbo slightly swollen. Fold poorly developed, narrow, often not reaching the front margin. Valve most convex in the middle and with gentle slopes to the anterolateral and front margins. Slopes to the cardinal extremities long and gentle. Cardinal extremities flattened. Interarea long, slightly curved, moderately apsacline.

Brachial valve with moderate concavity, greatest in the midregion; distinctly sulcate in some specimens. Sulcus narrow, may or may not reach the anterior margin. Areas bounding most deeply concave part gently concave. Cardinal extremities flattened, deflected toward the pedicle valve.

Interior like that of *S. socialis*.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|-------|-------------|-----------|--------|
| Holotype | 8.0 | 7.3 | 11.3 | 14.0 | 1.8 | 2.4 |
| Paratype (117528b) .. | 7.1 | 6.8 | 10.5 | 12.4 | 1.8 | 2.1 |

Types.—Holotype: 117528a; figured paratype: 117529b; unfigured paratypes: 117528b; 117529a.

Horizon and locality.—Wardell formation and Wardell part of Dryden formation in Virginia: At Rye Cove and vicinity. Same formation in Tennessee: 50 yards north of the intersection at Thorn Hill on U. S. Highway 25E, Avondale (T.V.A. 162-SW) Quadrangle.

Discussion.—This differs from *S. socialis* in its still stronger costellae and the prominent beading on the fine costellae.

SOWERBYELLA SUBCARINATA (Ulrich)

Plate 200, C, figures 15-18

Plectambonites subcarinatus Ulrich (Ms.) in BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 126, pl. 31, figs. 9-15, 1926.

Although this species has been figured, it has never been described. The type lot contains 6 specimens, not one of which is well preserved. The adult specimens are all badly exfoliated, and the interiors are of young specimens. Consequently, the species is difficult to define. Despite these difficulties the feature that gives the specific name to the species—the narrow median fold—is sufficiently well developed to be distinct even in the peeled specimens. A description of the type material and a few additional topotypes is given below.

Shell of about medium size for the genus, wider than long but with the length and width variable. Cardinal extremities acute and often produced into small ears. Lateral margins nearly straight to oblique. Anterior margin broadly rounded, usually nasute. Surface multicostellate; costellae elevated, narrowly rounded, slightly narrower than the interspaces. Costellae in 3 generations; costellae of first 2 generations of about the same size at the margin; 1 to 2 costellae of the third generation intercalated between those of the first 2 along the margin. Costellae 6 to 10 in a millimeter at the front and from 80 to 120 in number. Spaces between costellae marked by moderately distant, elevated concentric fila.

Pedicle valve moderately strongly convex in lateral profile and with the greatest convexity in the posterior half. Anterior profile strongly convex with a hump at the middle, the sides convex and sloping moderately to the lateral margins. Median fold narrow, strong, often producing the front margin into a small, blunt nose. Umbo narrowly swollen; beak inconspicuous. Regions bounding sulcus swollen but not raised above level of fold; slopes to cardinal extremities steep. Interarea apsacline.

Brachial valve with greatest convexity along line of sulcus corresponding to the fold; flanks bounding sulcus gently convex or somewhat flattened. Cardinal extremities deflected.

Interior of pedicle valve with low median ridge extending for about one-third the length of the valve, forked at the front; diductor-adjustor field wide and subflabellate; inner surface coarsely papillose, thickened strongly in the antero-lateral and lateral regions, and less so at the front. Delthyrial callosity thick. Brachial valve with median septa low and moderately elevated at the front.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thick-ness | Height |
|-------------------------------------|--------|-----------------|----------|-------------|------------|--------|
| Lectotype (pedicle valve)..... | 8.7 | ? | 12.9 | 14.8 | ? | 3.2 |
| Paratype (pedicle valve 71525b).... | 7.8 | ? | 11.5 | 10.9 | ? | 2.6 ? |
| “ (“ “ 71525c).... | 7.4 | ? | 10.4 | 12.1 ? | ? | 2.0 |
| Hypotype (brachial valve 117531e) . | ? | 5.7 | 9.0 | 10.4 | ? | ? |

Types.—Lectotype: 71525a; paratypes: 71525b-f; figured hypotypes: 117543a-d, 117534a-d; measured hypotype: 117531e.

Horizon and locality.—Carters formation in Birmingham (30') Quadrangle, Alabama: On Cedar Mountain 2 miles southwest of Argo; quarry 0.3 mile north of Gate City.

Discussion.—The most prominent feature of this shell is the narrow median fold of the pedicle valve which gives the name to the species. No description of this species was offered when the name was proposed, the name resting on 7 retouched pictures. The material on which the species is based is poorly preserved, and most of the specimens of the exterior are partially exfoliated. The median fold in itself is not a very distinctive feature because a tendency to such fold seems to exist in nearly all the species.

Sowerbyella subcarinata is a proportionately wider species than *S. nasuta* which is one of the most prominently folded species in the Appalachians. Of other somewhat carinate forms, this species is distinguished from *S. negritus* and *S. plicatifera* by their different ornamentation. The species is more convex than *S. lebanonensis*. *Sowerbyella compacta* is very close to *S. subcarinata*, and a few folded specimens are almost identical in profile and proportions to the Alabama shell. Folding in *S. compacta* is not the rule, and the specimens that so strongly resemble *S. subcarinata* are unusual ones.

SOWERBYELLA VARIABILIS Cooper, new species

Plate 197, D, figures 35-43; plate 202, E, figures 27-40

Shell of about medium size for the genus, wider than long, outline semielliptical to subrectangular; hinge forming the widest part, usually auriculate in the young and young adult. Sides varying from slightly to moderately oblique; anterior margin broadly rounded. Surface marked by costellae of unequal size, the 2 sizes alternating frequently; 3 or 4 of the strong costellae occupy the space of 1 mm. at the front margin; 1 to 4 of the finer costellae occupying the spaces between the stronger ones. Alternation of costellae less marked on the pedicle valve than on the brachial valve and more pronounced on the front of the pedicle valve than other parts of that valve.

Pedicle valve fairly strongly and evenly convex and with the maximum con-

vexity located at about the middle; anterior profile strongly convex in the middle with long and moderately steep and somewhat concave lateral slopes. Beak small, umbo somewhat swollen, the swelling continued forward as a poorly defined fold; flanks gently swollen and descending fairly steeply to the lateral slopes; anterior slope long and steep.

Brachial valve deeply concave with the deepest part forming a poorly defined sulcus extending from umbo to anterior margin; areas bounding sulcus less concave than the median region; subperipheral regions concave. Interior with slightly divergent median septa elevated near the middle; subperipheral rim moderately thickened; anterior slope moderately thickened, pustulose, and steep.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 7.7 | 7.1 | 12.2 | 13.4 | 1.6 | 2.7 |
| Paratype (117536a) .. | 6.1 | 5.8 | 9.6 | 12.0 | 1.2 | 2.0 |
| " (117537) ... | 7.5 | 7.1 | 12.1 | 14.2 ? | 1.5 | 2.6 |

Types.—Holotype: 117536b; figured paratypes: 117535b,c, 117536a, 117538a, 117539a,b; measured paratype: 117537.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek near center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County; Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County; (370 to 390 feet above base), creek bed west of U. S. Highway 77, SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County.

Discussion.—This species is a thin-shelled form characterized by considerable depth to the brachial valve, fine, beaded costellae, alate cardinal extremities, moderate convexity, and well-differentiated costellae. This species differs from *S. vulgata*, another Oklahoma species with which it might be confused, in the differentiated costellae, those of *S. vulgata* not being so well grouped as those of *S. variabilis*. This feature of the costellae distinguishes *S. variabilis* from similar appearing Appalachian species such as *S. compacta* and *S. socialis*. *Sowerbyella lebanonensis* has differentiated costellae, but its outline and profiles are different from those of the Oklahoma species. *Sowerbyella perplexa* has more regularly differentiated costellae than *S. variabilis* and has differently shaped valves.

SOWERBYELLA VARICOSTELLATA Cooper, new species

Plate 196, A, figures 1-8

Shell small, width at hinge not quite twice the length; anterior margin broadly rounded; lateral margins gently convex. Cardinal extremities acute, subalate. Posterior margin nearly straight. Surface marked by costellae of unequal size that appear in 4 generations. On the pedicle valve the median costella of the first generation is the strongest one and has the greatest size and height. On each side of this costella the flanks are marked by 2 to 3 first generation costellae that extend from the beak to the front margin. Within the areas marked off by these major costellae 3 generations of costellae may be counted. The second

generation is almost of the same size as those of the first generation. These 2 generations of costellae separate 2 to 7 of the finer costellae; 14 to 16 costellae may be counted in 2 mm. at the front of a specimen of average size.

Pedicle valve of even and moderately strong convexity; most convex portion at about the middle. Anterior profile unevenly convex with the greatest convexity at the middle and with the sides flat and sloping moderately to the margins. Beak inconspicuous, protruding very slightly beyond the posterior margin. Umbo narrowly swollen and passing into the swollen midregion. Slopes to the cardinal extremities very slight concave, gentle. Anterolateral regions somewhat swollen, occasionally with an obscure plication defined by the strong costellae. Interarea slightly curved, apsacline.

Brachial valve moderately convex with the greatest convexity located at about the middle and decreasing anteriorly and laterally. Flanks bounding most concave portion gently convex and with the convexity decreasing most rapidly laterally. Cardinal extremities deflected slightly toward the pedicle valve. Interarea short and hypercline.

Interior: Pedicle valve with median ridge short, extending for about one-quarter the length; diductor scars deeply impressed, strongly thickened along their inner margins. Outer margins strongly thickened. Internal surface strongly spinose. Brachial valve with median ridge unusually strong; lateral septa low; none of the septa strongly elevated at the front. Median elevation of valve moderately strong, thickened at the front and with several spinous processes projecting anteriorly from the front.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 4.6 | 4.0 | 7.0 | 7.5 | 1.7 | 1.9 |
| Paratype (117533)..... | 4.9 | ? | 7.3 | 8.7 | ? | 1.3 ? |
| " (117532e).... | 4.8 | 4.4 | 7.3 | 8.5 | 1.4 | 1.9 |
| " (123256a).... | 5.5 | ? | 8.8 | 11.4 ? | ? | 1.8 |
| " (123256c).... | ? | 4.9 | 8.7 | 11.8 ? | ? | ? |

Types.—Holotype: 117532a; figured paratypes: 117532b-d; unfigured paratypes: 117532e, 117533, 123256a-d.

Horizon and locality.—Arlene formation (middle and upper) in Tennessee: On both sides of the old road in the cedar glade, $\frac{1}{4}$ mile southeast of Friendsville; 100 yards south of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; $\frac{1}{4}$ mile south of McMullens, Meadow (T.V.A. 139-NW) Quadrangle; 3 miles southeast of Knoxville.

Little Oak formation in Alabama: 7 to 8 miles northeast of Branchville, St. Clair County.

Discussion.—This is a small species with moderately folded pedicle valve, well-differentiated costellae, moderately concave brachial valve, and acute cardinal extremities. It is distinguished from *S. negritus* by the lesser breadth of the zones of fine costellae set off by the larger radii, smaller size, and less prominent median folding. It is close to *S. silicica* but differs in having wider and more

regular zones of fine costellae, thus being intermediate between *S. negritus* and *S. silicica*.

SOWERBYELLA VULGATA Cooper, new species

Plate 198, A, figures 1-22; plate 202, C, figures 16-23; plate 206, B, figures 8-12

Shell of about medium size for the genus, wider than long, hinge forming widest part; semielliptical in outline; sides gently to moderately oblique; anterior margin rounded; costellae subequal in size, fairly crowded, variable but ranging between 5 and 6 to the millimeter at the front margin.

Pedicle valve fairly evenly and moderately convex in lateral profile; anterior profile broadly and gently convex, the median region broadly swollen with gently convex, moderately steep alopes. Umbo narrowly swollen, the swelling extended anteriorly to form a low fold; interarea steeply apsacline.

Brachial valve deeply concave and with a fairly well defined sulcus running from umbo to anterior margin; flanks moderately concave.

Pedicle interior with wide and short diductor scars and moderately long, thick septum separating them. Brachial interior with low median septa and broad and long adductor scars. Anterior slope long and fairly steep.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 7.4 | 7.0 | 11.0 | 12.5 | 1.5 | 2.2 |
| Paratype (117543b) .. | 7.2 | 6.9 | 10.5 | 11.4 ? | 1.6 | 2.2 |
| " (117543f) .. | 6.3 | 6.0 | 9.1 | 9.7 | 1.6 | 1.9 |
| " (117543g) .. | 6.4 | 6.1 | 10.0 | 11.1 | 1.3 | 2.0 |
| " (117540a) .. | 7.1 | 6.9 | 11.0 | 13.0 | 1.5 | 2.4 |
| " (117541a) .. | 6.3 | 6.1 | 10.4 | 12.0 | 1.4 | 2.0 |
| " (117541e) .. | 6.9 | 6.4 | 10.0 | 12.2 | 1.5 | 2.2 |

Types.—Holotype: 117543a, figured paratypes: 117540a-d, 117541a, 117542a, b,e, 117543b-d,f; unfigured paratypes: 117541b-e, 117542c,d, 117543e,g.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: In the road cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County; Mountain Lake, E $\frac{1}{2}$ sec. 22, T. 2 S., R. 1 W., Carter County; on Tulip Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 2 S., R. 1 E., Carter County.

Discussion.—This is a variable species characterized by moderate size and convexity, moderately concave brachial valve and poorly differentiated costellae. It differs from *S. plicatifera* and *S. variabilis*, both Oklahoma species, in lacking marked differentiation of the costellae. The species is suggestive of *S. compacta* of the Appalachian Valley region in size, shape, and profiles but is a more deeply concave and less robust species. It differs from *S. socialis* in having much finer and less strongly beaded costellae.

The costellae of this species are somewhat variable, specimens occurring with moderately strong costellae but others in which the radii are distinctly finer. No clear-cut separation between the two kinds proved possible and they are regarded as constituting one species.

SOWERBYELLA sp. 1

Plate 268, A, figures 1, 2

Small, semielliptical in outline, wider than long; sides gently convex, slightly oblique; surface with differentiated costellae, 2 of the larger costellae in the space of 1 mm. and the space between the larger costellae occupied by 2 to 4 fine costellae.

Pedicle valve moderately convex and with the greatest convexity at about the middle; anterior profile broadly convex, the median region slightly narrowed; lateral slopes long and moderately steep. Median region with a narrow but indistinct fold; flanks gently convex.

Brachial valve moderately concave, deepest in the median region but flattening laterally to the posterolateral extremities which are flattened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|---------------|--------|-----------------|----------|-------------|-----------|--------|
| 117544a | 6.8 | 6.2 | 9.8 | 11.4 | 1.3 | 2.2 |
| 117544b | 7.1 | 6.6 | 10.2 | 10.5 | 1.8 | 2.4 |

Figured specimen.—117544a; measured specimen: 117544b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: 68 to 84 feet above the basal sand on Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species suggests *S. vulgata* but is smaller, more swollen medially and umbonally, and with well-differentiated costellae.

SOWERBYELLA sp. 2

Plate 204, B, figures 6-12

Shell of about medium size for the genus, semielliptical in outline; wider than long and with the hinge forming the widest part; cardinal extremities auriculate; sides gently rounded, slightly to moderately oblique depending on age; anterior margin broadly rounded; costellae differentiated into fine and coarse, 2 of the latter occupying 1 mm. at the front and 2 to 4 of the former visible between the larger costellae.

Pedicle valve gently convex in lateral profile, the greatest convexity located just anterior to the umbo and with the front half somewhat flattened. Anterior profile forming a low mound highest in the middle and with long, gentle lateral slopes. Median region moderately swollen.

Brachial valve moderately concave and with an indistinct narrow sulcus extending from umbo to anterior margin; flanks moderately concave; posterolateral extremities flattened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|---------------|--------|-----------------|----------|-------------|-----------|--------|
| 117545a | 10.7 | 10.0 | 14.5 | 15.7 ? | 2.5 | 3.6 |
| 117545c | 8.4 | 8.1 | 11.4 | 13.4 ? | 1.6 | 2.3 |

Figured specimens.—117545a,b; measured specimen: 117545c.
Horizon and locality.—Rodman member of Nealmont formation in Pennsylvania: 1 mile northeast of Bellefonte, Bellefonte (15') Quadrangle.
Discussion.—This species is suggestive of *S. monilifera* from Iowa but is proportionally longer, has a more erect pedicle beak, less swollen pedicle valve, and shorter pedicle interarea.

SOWERBYELLA sp. 3

Plate 196, G, figures 45-50

Shell small, wider than long, hinge equal to or wider than the midwidth depending on age; costellae well differentiated, 2 of the larger costellae occupying 1 mm. and as many as 5 costellae separating the larger ones at the front margin; posterior margin of both valves marked by prominent oblique wrinkles. Pedicle valve moderately convex and with the greatest convexity near the middle in lateral profile; anterior profile broadly and moderately convex; umbo and median region broadly swollen and merged with the flanks. Brachial valve with the maximum concavity in the umbonal region, rest of valve moderately concave; posterolateral extremities flattened.

Measurements in mm.—117546, length 6.9, brachial length 6.5, midwidth 10.1, hinge width 11.2 ?, thickness 1.3, height 2.1.

Figured specimen.—117546.
Horizon and locality.—Lower part of the dark shale under the Eureka quartzite in Nevada: On the north-facing nose of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This is a small species with well-differentiated costellae which is less deep than *Sowerbyella* sp. 1. It is suggestive of *S. silicica* but is larger and does not have the small fold and sulcus of that species. It differs from *S. varicostellata* in not having the pedicle valve subcarinate and the brachial valve distinctly sulcate.

SOWERBYELLA sp. 4

Plate 196, B, figures 9-14

Shell small, wider than long; hinge wide, cardinal extremities auriculate; 2 large costellae occupying 1 mm. at the front margin and large costellae separated by a maximum of 5 fine costellae. Pedicle valve gently convex in lateral profile; anterior profile narrowly rounded in the middle with the sides somewhat depressed and sloping steeply to the margins. Median region subcarinate; fold low; flanks gently inflated. Brachial valve not deeply concave, deepest along the median line in the form of a narrow sulcus extending from umbo to anterior margin. Sides gently convex to flattened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|---------------|--------|-----------------|----------|-------------|-----------|--------|
| 117547 | 6.1 | 5.7 | 8.4 | 8.3 ? | 1.3 | 1.9 |
| 117548a | 5.1 | 4.9 | 6.9 | 8.0 | 1.4 | 2.0 |
| 117548b | 5.3 | 5.1 | 7.3 | 8.2 | 1.2 | 1.7 |

Figured specimens.—117548a,b; measured specimen: 117547.

Horizon and locality.—Yellow shaly limestone above 25-foot sandstone of Eureka group in Nevada: Saddle just north of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is suggestive of *S. silicica nana* in its possession of a fold and sulcus, but it has a much less swollen and less carinate pedicle valve, although one brachial valve is more deeply concave medially.

Genus **CHONETOIDEA** Jones, 1928

Chonetoidca JONES, Mem. Geol. Surv. Great Britain, Paleont., vol. 1, pt. 5, p. 393, 1928.

CHONETOIDEA VIRGINICA Cooper, new species

Plate 215, H, figures 30-33

Shell small, wider than long with the hinge forming the widest part; cardinal extremities subacute; sides slightly oblique; anterior margin broadly rounded; multicostellate, costellae uneven in size; about 12 of the large ones may be counted at the front margin, but only 6 of these reach the umbo. Space between larger costellae marked by numerous fine threads.

Pedicle valve gently convex in lateral and anterior profile; median region subcarinate; flanks somewhat flattened. Interior without dental plates but with a short, thin median septum occupying the delthyrial region. Muscle field small, diductor scars subparallel and short. Anterior margin marked by numerous short striae.

Brachial valve flat to slightly concave in anterior and lateral profiles. Umbo concave; rest of valve nearly flat. Interior with short brachiophores, narrow and shallow notothyrial cavity and short median ridge located at about the middle of the valve. Lateral ridges in the form of elongate nodes or short ridges, 3 or more on each side of the median ridge and the inner 2 of them located close to the median ridge. Adductor field large.

Measurements in mm.—Holotype, length 3.2, brachial length 2.8, midwidth 4.3, hinge width 5.5, thickness ?.

Types.—Holotype: 111097c; figured paratypes: 111097a,b; unfigured paratype: 111097d.

Horizon and locality.—Edinburg formation (Liberty Hall facies) in Virginia: From a bluff on the north fork of the Shenandoah River $\frac{1}{2}$ mile above the south fork, opposite the bridge, Riverton, west of Front Royal, Front Royal (15') Quadrangle.

Discussion.—No other American species of this genus is now known to which this one can be compared. It differs from the British species *C. papillosa* (Reed) in having the costellae separated into fairly regular groups by the larger costellae, in having a nearly flat brachial valve, and in details of the brachial interior.

ANISOPLEURELLA Cooper, new genus

(Greek *an*, not; *isos*, equal; *pleuron*, rib)

Shell small in all known species, wider than long with the hinge forming the widest part. Cardinal extremities acutely angular, often alate. Lateral profile

concavo-convex. Interareas as in *Sowerbyella*. Surface of both valves ornamented by costellae of unequal size; a few stronger costellae stand out in a field of finer, closely crowded costellae which may be cancellated by concentric fila. Pseudodeltidium of pedicle valve well developed; chilidium highly arched.

Inside the pedicle valve the muscle field is small and confined to the posterior quarter of the valve. Adjustor-diductor impressions small, widely divergent, not separated by a septum. Brachial cardinalia like *Sowerbyella* with cardinal process frozen to the brachiophore bases to form an inverted V. Brachial processes long and slender, nearly parallel to the posterior margin. Adductor field bilobed with the ends of the lobes thickened; anterior and posterior patches of each lobe separated by a prominent septum pointing toward the anterolateral curve of the front margin. Median septum short, located at about the center and mostly confined to that part of the valve. Two pallial trunks originate at the end of the median septum.

Genotype.—*Anisopleurella tricostellata* Cooper, new species.

Discussion.—This is an uncommon genus now known chiefly from limestone associated with black shales. It occurs in Great Britain as the Upper Bala "*Sowerbyella*" *quinquecostata* McCoy. This interesting little shell may be identified by its generally sowerbyelloid form, generally low convexity, and two sizes of costellae. The interior of the brachial valve is also distinctive in the rounded adductor areas on each side of a low and delicate median septum. These areas are usually oval in outline, the narrow part of the oval directed posteromedially and the expanded part facing the anterolateral extremity. The areas are bounded by a curved and elevated rim, and each is divided more or less evenly by a short oblique ridge. The cardinalia are like those of *Sowerbyella*, but the cardinal process was not seen as a vertical ridge although the tentlike structure is present.

ANISOPLEURELLA INAEQUISTRIATA Cooper, new species

Plate 193, B, figures 5-9

Shell small, width between $2\frac{1}{2}$ and nearly 3 times the length. Cardinal extremities acute, with small ears. Lateral margin strongly indented just anterior to the ears in young specimens but very slightly rounded and oblique in adults. Anterior margin broadly rounded to nearly straight. Commissure uniplicate except at the cardinal extremities. Surface multicostellate, marked by costellae of 3 sizes. On the young and the more youthful adults the shell is divided into 4 sectors of about 45° each by 3 strong costellae, 1 central one, and 2 lateral ones that extend to the anterolateral margins. In older adults the prominence of these 3 costellae at the front of the valve is obscured by the presence of many costellae of intermediate size, but even in these older specimens the 3 major costellae stand out. The 2 stronger sets of costellae are set in a bed of very fine costellae about 17 in 1 mm. This figure usually includes at least 2 costellae of intermediate size of which there are about 21 including the 3 primary costellae. All the costellae are cancellated by fine concentric fila. In addition to these, fine concentric undulations are present.

Pedicle valve unevenly convex with the greatest convexity in the anterior half

where the valve is somewhat geniculated and the posterior half flattened. Anterior profile a very gentle bow with the highest part in the middle. Posterior margin nearly straight. Beak and umbo swollen and standing above the posterior margin and with the beak protruding slightly beyond the posterior margin. Central part slightly swollen and more prominent than the flanks which extend by a gentle slope to the cardinal extremities. Anterior and lateral slopes steep.

Brachial valve with moderately concave umbonal region but strongly concave in the median part. Flanks bounding deepest part somewhat flattened. Cardinal extremities deflected toward the pedicle valve. Interarea anacline.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|--------------------------|--------|-------|-------------|-----------|
| Holotype | 4.3 | 9.6 | 11.5 | ? |
| Paratype (110929b) | 3.8 | 7.3 | 9.7 | ? |
| " (110929c) | 4.2 | 8.0 | 8.9 | ? |

Types.—Holotype: 110929a; figured paratypes: 110924, 110929b-d.

Horizon and locality.—Whitesburg formation in Tennessee: 1½ miles west of Bulls Gap, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Chatham Hill formation in Virginia: On the Grayson Farm, 4 miles southwest of Bland, Bland County.

Discussion.—Compared to *A. tricastellata*, this species is much larger, more convex, and has more numerous large costellae.

ANISOPLEURELLA TRICOSTELLATA Cooper, new species

Plate 193, A, figures 1-4; plate 195, A, figures 1-5

Shell small, about twice as long as wide at the hinge; cardinal extremities acutely angular; lateral margins slightly convex, front margin broadly rounded. Surface marked by costellae of unequal size; 3 costellae stronger than the others divide the shell into 4 parts; 1 costella originates at the umbo and extends to the anterior margin, the other 2 extend to the anterolateral margins. The surface between the stronger costellae are marked by very fine, crowded costellae of unequal size and numbering about 12 or 13 in 1 mm. at the front margin. Costellae cancellated by fine concentric fila. Flanks marked by interrupted concentric undulations.

Pedicle valve moderately convex, with the greatest convexity at about the middle; beak protruding very slightly beyond posterior margin; umbo swollen; portion of shell occupied by 2 medial quadrants as marked off by strong radii inflated; outer flanks flattened; posterior margin defined by a thickened rib or costella diminishing in size toward the beak.

Brachial valve gently concave with the maximum depression at the middle; flanks and cardinal extremities somewhat flattened. Adductor field forming 2 well-rounded and large lobes, each lobe divided by an oblique ridge; median septum short and slender. Cardinalia as in *Sowerbyella*.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 2.9 | 2.6 | 5.0 | 6.4 | 0.4 | 0.8 |
| Paratype (110925a).... | 3.8 | ? | 6.4 | 8.9 ? | ? | 0.7 |
| " (110925b).... | 3.9 | ? | 6.7 | 7.8 | ? | 1.1 |

Types.—Holotype: 117475b; figured paratypes: 110925a-d, 117475a; unfigured paratype: 117475c.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its low convexity and the presence of 3 prominent costellae, 1 median one and 2 lateral ones. These features distinguish this species from *A. inaequistriata* which is more convex and has numerous large costellae.

Genus EOPLECTODONTA Kozłowski, 1929

Eoplectodonta KOZŁOWSKI, Palaeont. Polonica, vol. 1, No. 1, pp. 30, 113, 1929.

This genus was proposed for sowerbyelloids having a partially denticulate hinge line. Actually the genus has some combinations of ornamentation and interior characters that will serve to distinguish it from *Sowerbyella* and other members of the Plectambonitacea.

All the known species of *Eoplectodonta* are characterized by ornamentation in which larger costellae define bands of smaller radii of greater or less width. The species also are characterized by a prominent oblique wrinkling of the posterior margins. These features occur in some other genera, such as *Sowerbyella*, but in that genus the wrinkling of the hinge is usually a variable feature whereas it appears to be constant in *Eoplectodonta*. Furthermore, no species of *Eoplectodonta* is now known in which the finer costellae are beaded as in American Porterfield, Wilderness, and Trenton species.

Inside the pedicle valve the arrangement of the muscle and pallial trunks is like that of *Sowerbyella*, but *Eoplectodonta* does not have the forked arrangement at the anterior end of the septum so common in the former genus. Inside the brachial valve the feature of most importance is the development of the median septum to a stage equal to or surpassing that of the lateral septa. This produces 3 almost uniform septa which are only slightly divergent. These rise to a crest near the center of the valve as in *Sowerbyella* and usually have a steep papillose anterior slope. The triradiate pattern of the septa is very distinctive. This feature appears in one species of *Sowerbyella* and suggests that *Sowerbyella* is the ancestor of *Eoplectodonta*.

Eoplectodonta is well represented in the British Llandovery fauna which includes *E. praecursor*, the genotype, and *E. duplicata*. *Plectambonites schmidtii* Tørnquist of Etage 5b from Norway appears to belong here. The American species are much older than the British forms.

EOPLECTODONTA ALTERNATA (Butts)

Plate 184, A, figures 1-3; plate 207, B, figures 2-25; plate 208, A, figures 1-18;
plate 269, E, figures 23, 24

Sowerbyella alternata BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 109, pl. 95, figs. 22, 23, 1942.

Sowerbyella sp., *ibid.*, p. 109, pl. 95, figs. 20, 21.

Shell large, wider than long, length about two-thirds the width. Cardinal extremities acute or rounded and obtuse, depending on age. Lateral margins nearly straight or moderately rounded. Anterior margin broadly rounded to nasute. Anterior commissure sulcate. Hinge forming widest portion of shell in young but narrower than width at middle in old valves. Surface multicostellate, costellae of unequal size, about 30 of the larger ones at the front margin separated by from 3 to 10 of the finer ones. The latter costellae are low, rounded, crowded, and with interspaces much narrower than the costellae. Larger costellae rounded and elevated. Fine concentric fila and wrinkles along the posterior margin complete the ornamentation; as many as 18 wrinkles occurring on each side of the beak.

Pedicle valve with low beak, protruding very slightly posterior to the posterior margin. Umbo slightly swollen, extended forward as a low, narrow fold. Anterior profile narrowly arched with the greatest height at the narrow fold and the gently convex sides sloping steeply to the margins. Lateral profile with the greatest convexity located in the umbonal region. Cardinal extremities deflected toward the pedicle valve to form small ears. Interarea curved, orthocline. Pseudodeltidium strongly arched, fairly large.

Brachial valve deeply concave with the deepest part in the posterior half; not strongly sulcate. Cardinal extremities deflected toward the pedicle valve; interarea nearly flat and usually nearly in a plane with the interarea of the pedicle valve and therefore nearly orthocline in position.

Pedicle valve with muscle field short, extending about one-quarter the length; adjustor-diductor marks elliptical in outline, widely divergent, separated by a short, stout median ridge. Adductor impressions forming small pits. Teeth small; hinge denticles about 6 or 7 in number. Entire surface papillose. Brachial valve with septa extending to about the middle where they are moderately elevated. Median septum stronger than the lateral septa. Adductor impressions indistinct.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Lectotype | 11.0 | ? | 15.6 ? | ? | ? | 4.4 |
| Hypotype (79419a)..... | 12.7 | ? | 17.8 | 17.2 | ? | 5.0 |
| " (79419b)..... | 13.8 | ? | 19.0 | 20.8 | ? | 6.7 |
| " (110993d)..... | 12.0 | 12.0 | 20.3 | 21.6 | ? | ? |
| " (117551-l) | 16.1 | ? | 20.7 | 19.6 | ? | 8.0 |
| " (117552)..... | 13.8 | 11.0 | 19.3 | 20.2 | ? | 4.9 |
| " (117550b)..... | 13.7 | 11.2 | 18.2 | 18.0 | 3.1 | 6.1 |
| " (117550c)..... | 13.3 | 11.1 | 18.2 | 16.0 | 3.7 ? | 5.7 |
| " (117550d)..... | 13.1 | 11.4 | 19.0 | 18.0 | 2.7 | 5.5 |

Types.—Lectotype: 97544a; paratypes: 97543a-c; figured hypotypes: 79419a, d-g, 110985, 110993a-h, 111798a,b, 117549a, 117550b,d, 117551g,l,n,q, 124231a,b; measured hypotypes: 79419b, 117550c, 117552.

Horizon and locality.—Oranda formation in Virginia: North of the road 0.6 mile northwest of Linville Station; just west of the junction of Virginia County Highways 617=910, and 777, on 777, $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle. Along the railroad $\frac{1}{4}$ mile west of Strasburg; on U. S. Highway 11, 2 miles southwest of Strasburg, Strasburg (15') Quadrangle; just east of Battlefield Crystal Caverns, 1 mile north of Strasburg; Bowman Farm, 0.3 mile east of U. S. Highway 11, south edge of Woodstock, Edinburg (15') Quadrangle; south side of U. S. Highway 33, 0.2 mile west of Harrisonburg city limits, Harrisonburg (15') Quadrangle.

Basal Martinsburg formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia County Highway 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Oranda formation in Pennsylvania: 1 mile northwest of Guilford Springs, 2 $\frac{1}{2}$ miles southwest of Chambersburg, Chambersburg (15') Quadrangle; Carlisle, Carlisle (15') Quadrangle; 1 mile south of St. Thomas, Mercersburg (15') Quadrangle.

Salona formation in Pennsylvania: On Fishing Creek at Salona, Lock Haven (15') Quadrangle.

Dark shale under Eureka quartzite in Nevada: In the north-facing nose of hill 8167, and 4.2 miles north-northeast of Martin Ranch, Monitor Range; under 2 knobs of Eureka quartzite, north side canyon, 3.1 miles N. 32° E. of Blair (Segura) Ranch, Antelope Mountains, Roberts Mountains (1°) Quadrangle.

Discussion.—This species can generally be recognized by its large size, usually strongly convex pedicle valve, the beautiful ornamentation and the elaborate wrinkling of the posterior margins of both valves. As here described the species occurs in the Oranda and succeeding Salona formation, particularly near Green Mount Church north of Harrisonburg.

Eoplectodonta alternata was originally inadequately described, the description consisting of two lines and the comparison being made to another species belonging to a different genus. The cotypes consist of four specimens, all of them poor. The best specimen, 97544a, is selected as lectotype. This specimen shows the ornamentation and the general form of the species, but no other details are preserved.

This species is quite variable in profile and outline. Some of this variability has to do with age of the specimens and some of it with preservation. The younger specimens are flatter than the older ones and the beak is often visible when the shell is viewed from the full exterior. In the older adults the beak migrates anteriorly as the shell grows, and the beak is obscured in the same view by the swollen umbonal region. The development of the fold on the pedicle valve is also a variable feature. In some specimens no distinct fold is visible, but in others

the fold is narrowly rounded and conspicuous, often causing the anterior margin to become somewhat nasute. In one specimen 2 narrow folds were produced, but this is quite unusual.

Eoplectodonta alternata is not likely to be confused with any other known species in lower Middle Ordovician rocks. Its large size, tumid valves, rounded sides, strong wrinkling, and the good development of denticles all distinguish it from *E. ? dubia*. The form and convexity of the valves differentiate this species from *E. foerstei*.

EOPLECTODONTA ? DUBIA Cooper, new species

Plate 207, A, figure 1; plate 209, C, figures 8-13

Shell of about the usual size for the genus, wider than long, with the width at the hinge not quite twice the length. Cardinal extremities acute, often alate. Anterior margin broadly rounded; lateral margin variable. Surface marked by costellae of unequal size; young shells marked by about 11 strong costellae separated by about 10 fine, crowded lines. In full-grown specimens the sectors defined by the primary strong costellae are divided by costellae of intermediate size, and these are separated from the larger costellae by 4 to 10 of the fine costellae. About 7 costellae occupy a space of 1 mm. at the front margin. Posterior margin wrinkled.

Pedicle valve gently convex in lateral profile with the greatest convexity in the posterior portion of the valve. Center part swollen to form a low fold. Flanks slightly convex, descending to the cardinal extremities with a gentle slope. Interarea apace line.

Brachial valve with the greatest concavity in the umbonal and median regions, somewhat flattened in the vicinity of the cardinal extremities and anterolateral region. Interarea hypercline.

Interior: Pedicle valve with adjustor-diductor impressions short, deeply impressed, somewhat elliptical in outline. From the anterior end of this muscle field a strong pallial trunk is sent out anterolaterally. Dental plates short, prominent, not hidden by callus. Accessory dental arrangement obscure, if present. Inside the brachial valve 3 septa extend to about the middle of the valve; the median septum is the highest and best developed of the 3. Interior of both valves strongly granulose. No hinge denticulations seen.

Measurements in mm.—

| | Length | Midwidth | Hinge width | Thickness |
|---------------------------------|--------|----------|-------------|-----------|
| Holotype (pedicle valve)..... | 10.1 | 16.3 | 18.9 | ? |
| Paratype (" " 117555a)..... | 9.3 | 14.4 | 18? | ? |
| " (" " 117555b)..... | 8.3 | 13.7 | 16.2 | ? |
| " (" " 117555c)..... | 8.0 | 14.1 | ? | ? |
| " (brachial valve 117555e)..... | 6.7 | 10.1 | 13.0 | ? |
| " (" " 117555h)..... | 7.8 | 10.9 | 13.5 | ? |

Types.—Holotype: 117555d; figured paratypes: 110984, 117555b,f-h; unfigured paratypes: 117555a,c,e.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Virginia: Ravine on south side railroad, $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle.

Botetourt formation in Virginia: Junction Virginia Highways 731 and 724, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle.

Discussion.—This species is placed in *Eoplectodonta* with a query because no denticles were seen along the hinge in any of the specimens studied. Although the hinge seems to be edentate, the other characters, internal and external, seem to be those of *Eoplectodonta*. On the outside the ornamentation with its large costellae separating broad bands of fine radii and the prominent wrinkling along the posterior margin are all characteristic features of *Eoplectodonta*. On the inside of the brachial valve prominent development of the median septum is characteristic although the development of the muscle callosities and the narrowed, elevated front are not carried to the extent that is usual in geologically younger species.

Eoplectodonta ? *dubia* differs from *E. foerstei* and *E. alternata* in having less robust and convex valves and in lacking hinge denticulations.

EOPLECTODONTA FOERSTEI Cooper, new species

Plate 209, A, figures 1-3

Shell moderately large, wider than long with the length equal to about two-thirds the width. Cardinal extremities acute and mucronate in the young but rounded and obtuse in large adults. Lateral margins of adult gently rounded; anterior margin broadly rounded. Surface marked by costellae of several sizes. In the half-grown stage the ornamentation consists of costellae of 3 sizes, the larger costellae standing out prominently and producing a slight plication of the valve and separated by about 10 of the finer costellae. Among the finer costellae occurs an occasional costella of intermediate size. In the adult half of the shell costellae of the stronger and intermediate sizes predominate and are separated by 1 to 4 finer costellae. In the young half of the valve strong oblique wrinkles, about 8 on each side of the hinge, are conspicuous. These are not carried on in the later growth stages and are thus confined to the young half of the valve. Fine concentric growth fila complete the ornamentation.

Pedicle valve only gently convex in the young and with a fairly prominent low fold in the posterior half. Lateral profile of the adult strongly convex with the greatest convexity in the posterior third. Anterior profile of adult forming a very convex arch with steeply sloping sides. Fold of the young stages lost before the middle of an adult. Anterior half of an adult somewhat tumid and with moderately steep slopes to the margins. Slopes to cardinal extremities concave and steep. Cardinal extremities deflected toward the pedicle valve. Beak small, protruding slightly beyond the posterior margin. Interarea slightly curved and orthocline in position. About 14 denticles are visible on one side of the hinge of No. 11092c, but this may not be the full complement because this side of the valve is broken.

Exterior of pedicle valve unknown.

Interior: A fragment of brachial valve preserving the front portion and the ends of the median septa shows the middle septum to be highest and longest of the 3 as usual in the genus.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Thickness | Height |
|-------------------------------|--------|-----------------|-----------|-------------|-----------|--------|
| Holotype (pedicle valve)..... | 11.9 | ? | 17.7 | 16.9 ? | ? | 4.2 |
| Paratype (" " 110992b)..... | 10.8 | ? | 17.2 ? | ? | ? | ? |
| " (" " 110992f)..... | 7.7 | ? | 12.9 | 14.4 | ? | ? |

Types.—Holotype: 110992a; figured paratype: 110992d; unfigured paratypes: 110992b,c,e-f.

Horizon and locality.—Wells formation in Tennessee: Along the railroad, 1½ miles southwest of Cumberland City, Wells Creek Basin, Stewart County.

Discussion.—This species is proportionately wider and less convex than *E. alternata* which it approaches in size although it never attains the large dimensions of the Oranda and Salona species. The zones of fine costellae in the Tennessee species are less wide, and many more of the strong costellae appear in the ornamentation of *E. foerstei*.

EOPLECTODONTA ? TRIRADIATA (Butts)

Plate 203, B, figures 16-20

Sowerbyella rugosa triradiata BURRS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 113, pl. 96, fig. 9, 1942.

Shell small, somewhat trapezoidal in outline; the hinge forming the widest part; sides gently oblique; anterolateral extremities narrowly rounded; anterior margin straight. Surface marked by costellae of unequal size, 3 of which are more prominent than the others: 1 is median and the other 2 extend from the beak to the anterolateral extremities. Space between large costellae filled by a mat of finer costellae of 2 or 3 sizes.

Pedicle valve unevenly and narrowly convex in lateral profile, the posterior half convex, the anterior half flattened and the place of geniculation narrowly convex; anterior profile subrectangular, the median part nearly flat but the sides short and descending steeply. Umbo and beak small; region posterior to angle of geniculation gently convex; angle of geniculation about 85°; region posterior to angle shorter than the trail; anterior slope of trail long and steep; trail broadly sulcate in the median region; sides steep and set off from the trail by narrowly rounded anterolateral folds. Interarea long, apsacline.

Brachial valve and interiors not known.

Measurements in mm.—

| | Length | Midwidth | Hinge width | Thickness | Height | Surface |
|------------------------|--------|----------|-------------|-----------|--------|---------|
| Holotype | 5.5 | 9.8 | 11.0 | ? | 1.4 | 5.8 |
| Hypotype (123257a).... | 6.6 | 9.1 | 9.5 | ? | 2.9 | 9.5 |

Types.—Holotype: 97582b; paratypes: 97582a,c; figured hypotype: 123257a.

Horizon and locality.—Oranda formation in Virginia: In the railroad cut $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species can be readily recognized by the 3 prominent costellae on the surface and the strong geniculation near the middle. The holotype briefly noticed by Butts is undoubtedly a youthful specimen which has not yet geniculated. The hypotype figured herein shows the full geniculation and indicates clearly that this species has nothing to do whatsoever with *S. rugosa* of the Eden and Martinsburg formations.

Sowerbyella ? *triradiata* Butts is most like *Plectambonites quinquecostata sublobata* Reed from the Balclatchie formation, Girvan District, Scotland. From measurements taken from Reed's figures it is evident that his species is a much larger one and apparently less strongly geniculated than the Oranda form. His has the same triradiate ornamentation so characteristic of Butts' species. An interior of a brachial valve figured by Reed suggests an interior like that of *Eoplectodonta* rather than *Sowerbyella*. It shows 3 closely spaced median septa and 2 lateral septa separating the adductor scars. No denticulations are noted along the hinge in either description or the figures.

EOPLECTODONTA sp. 1

Plate 192, E, figures 25-28

The specimen illustrated is of particular interest because it is probably a young one and because it shows clearly the partially denticulate hinge which is regarded as an important character of the genus. The small size and gentle contours of the profiles of this specimen are also indicators of youth. This specimen was taken from the siltstone 30 feet above *Echinosphaerites* zone in the lower part of the Edinburg formation in Virginia, $1\frac{1}{2}$ miles south of Wadesville, Winchester (15') Quadrangle. It thus indicates a fairly early appearance of the denticulate hinge line. This specimen is of approximately the same age as *E. ? dubia*, but none of the specimens of that species showed clear development of denticles.

Figured specimen.—117556.

Subfamily XENAMBONITINAE Cooper, new subfamily

Sowerbyellidae having a small elevated visceral disk.

XENAMBONITES Cooper, new genus

(Greek *xenos*, strange; *ambon*, umbo)

Shell small, semielliptical in outline; hinge wide, cardinal extremities acute; plano- to concavo-convex; anterior commissure deeply sulcate; surface finely costellate.

Pedicle valve with moderately long interarea; anterior with prominent, broad median fold; teeth small, simple; muscle area wide but short, somewhat rectangular in outline; dental plates vestigial; trough corresponding to fold anterior to muscle area may or may not be occupied by an inverted V-shaped cavity; ovarian

impressions fairly large, bounded on the side nearest the median line by a low ridge. Delthyrium open in the adult.

Brachial valve deeply sulcate, the sulcus on the inside forming a high, rounded ridge which serves as a median septum; sockets narrow, slitlike; brachiophores thin, short, flat blades intimately fused with a convex plate that arches over the notothyrium; a septumlike cardinal process and intergrown brachiophores forming an arched plate suggest the tentlike structure of *Sowerbyella*; visceral disk short, strongly elevated toward the pedicle valve, somewhat expanded laterally and produced into a long point anteromedially.

Genotype.—*Xenambronites undosus* Cooper, new species.

Discussion.—This genus is one of the most peculiar of all the plectambonitids. It will not be confused with any other because of its nearly horizontal wrinkling and the elaborate development of the anterior margins. The fold is very strong and is also well marked in the young. When adulthood is reached the pedicle-anterior wrinkles in the direction of the pedicle valve to form a narrow marginal fold which makes 2 concave areas of the anterior portion of the flanks. Internally the margin is marked by a carinate ridge which slopes obliquely inward toward the middle to form the slip over which the geniculated edge of the brachial valve fits.

The interior of the pedicle valve is somewhat suggestive of *Leptellina* in its short and wide, subrectangular muscle area which is lodged in the delthyrial cavity. The lateral margin is formed by vestigial dental plates which are barely visible. The anterior end of the muscle area is excavated to form an inverted V-shaped chamber as the median part of the valve deepens. A second V-shaped chamber may be developed in the trough of the pedicle valve anterior to the muscle area. This one is probably created by the main trunks of the vascula media which travel anteriorly on each side of the median trough. Not one pedicle valve showed clear-cut trace of a pseudodeltidium. The genus probably had one in young stages, but none of the young specimens preserves it.

The brachial valve has the anterior margin strongly geniculated toward the pedicle valve. This geniculated edge fits over the carinate subperipheral rim in the pedicle valve. The brachial valve thus forms a boxlike lid to the pedicle valve.

None of the brachial valves showed any clear trace of a vertical median septum on the tentlike brachial structures. The preservation is not good, but if such a septum were present a trace of it should appear. The arched plate which is welded to the brachiophores overhangs the peculiar visceral disk. The latter is short but strongly elevated. It is narrowly folded in the middle to form a low median ridge which extends somewhat obliquely toward the pedicle valve and is produced at its anterior extremity into a long, sharp point. The sides of the disk cover the anterior parts of the valve. No trace of pallial marks was seen on this portion of the valve, and the muscle marks were not differentiated in the visceral disk.

No genus is at present known to which this one will closely compare.

XENAMBONITES UNDOSUS Cooper, new species

Plate 195, D, figures 17-31; plate 268, F, figures 25-28

Shell small, semielliptical in outline, with the hinge forming the widest part; cardinal extremities narrowly rounded to mucronate; sides strongly oblique, nearly straight; anterior margin narrowly rounded. Surface marked by closely crowded, threadlike costellae and transverse wrinkles parallel to the hinge and located in the posterior half. Fold and sulcus bounded on each side by a costella stronger than the surrounding ones.

Pedicle valve gently convex in lateral profile but with the umbo somewhat narrowly rounded; anterior profile with median region narrowly humped up and sides depressed and gently concave; fold narrow and rounded and including the narrow, swollen umbo; sides of fold moderately steep; flanks gently swollen but depressed below the fold; anterior and lateral margins marked by a narrow convex fold which is moderately elevated in the anterolateral region. Interior margin with elevated, carinate peripheral rim.

Brachial valve uneven in lateral profile, the posterior half gently concave but the anterior half moderately convex; anterior profile with deep median sulcus bounded by high, narrow folds. Umbo gently concave, the concavity deepening anteriorly to form a deep and narrow sulcus; flanks narrowly convex in the anterior half but flat to gently concave in the posterior half; cardinal extremities flattened; margins deflected strongly toward the pedicle valve to fit over the subperipheral rim of the pedicle valve. Interior as described for the genus.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|-----------|-------------|-----------|
| Paratype (pedicle valve 117468a)..... | 3.8 | ? | 6.2 | 8.3 | 2.2 ? |
| “ (brachial valve 117468n).... | ? | 3.2 | 5.8 | 6.4 | 1.3 |

Types.—Holotype: 117468h; figured paratypes: 117468a,f,g,l,m,r; unfigured paratypes: 117468b-e,i-k,n-q,s.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species of this genus is now known to which this one may be compared. Furthermore, no other plectambonitid has a combination of features even remotely like this genus.

Subfamily PTYCHOGLYPTINAE Cooper, new subfamily

Sowerbyellinae with poorly developed septa in the brachial valve.

Genus PTYCHOGLYPTUS Willard, 1928

Ptychoglyptus WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 283, 1928.

Shell thin, rafinesquinoid in outline and profile; interareas well developed; interarea of brachial valve the shorter of the two; surface marked by costellae of 2 sizes and formed in several generations. A few large costellae originating at the apex and extending to the margin. Costellae of nearly the same size are

intercalated. Between these larger costellae fine radial lines extend from the beak to the margin. Between the larger costellae the shell is thrown into narrowly rounded, often chevron-shaped rugae. The rugae may lie obliquely between the costellae or they may form an inverted V.

Inside the pedicle valve the dental plates are of the receding type, short and poorly developed. The muscle area is small and nearly confined to the delthyrial cavity. Diductor impressions small. Vascula media short. Teeth small and sharp. Pseudodeltidium moderately arched, imperforate. Interarea apsacline.

Brachial interarea anacline; notothyrium partially closed by chilidial plates. Cardinalia sowerbyelloid. Brachiophores elongate, slender, supported by callus that joins the cardinal process, chilidial plates, and brachiophores into a tentlike structure. Internal median septa poorly formed, short but present near the middle of the valve.

Genotype.—*Ptychoglyptus virginiensis* Willard (by original designation), Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 283, pl. 2, fig. 12, 1928.

Discussion.—This genus was described originally as an ornate type of *Rafinesquina*, but examination of the interiors indicates that the affinities are with *Sowerbyella* rather than with *Rafinesquina*. Sowerbyelloid features are revealed by the ornamentation and the cardinalia.

Ptychoglyptus as now understood characterizes chiefly forms from the Effna formation and its correlates. This genus has been identified in other rocks than those laid down in Mohawkian time, but the interiors of the forms referred to the genus have not been described.

PTYCHOGLYPTUS ? KINDLEI Cooper, new species

Plate 172, B, figures 7-9; plate 172, C, figures 10-12

Wider than long, hinge forming widest part; sides obliquely sloping toward the middle; anterior margin broadly rounded; larger costellae in 2 or 3 generations, 6 or 8 on each side of the median line; rugae large, strong.

Pedicle valve faintly convex in anterior and lateral profile in the posterior three-quarters, more or less strongly geniculated toward the brachial valve in the anterior quarter; umbo gently and somewhat narrowly swollen; median region slightly convex; lateral and anterior slopes steep. Interior unknown.

Brachial valve nearly flat to gently concave in lateral profile and with the anterior quarter turned abruptly in the direction of the brachial valve. Umbo a hollow pit, median and flank regions gently concave.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-----------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 10.4 | ? | 12.7 | 15.2+ | ? |
| Paratype (66290b).... | ? | 7.2 | 12.4 | 13.7+ | ? |
| " (66290f).... | ? | 7.9 | 13.8 | 15.4?+ | ? |
| " (66290g).... | ? | ? | ? | ? | 1.0 |

Types.—Holotype: 66290c; figured paratypes: 66290a,b, 117392a-c, 123254a; unfigured paratypes: 66290d-g, 123254b.

Horizon and locality.—Boulder in Mystic conglomerate in Quebec, Canada: In Range 6, Lot 20, Stanbridge Township, about $2\frac{1}{2}$ miles north of Mystic.

Table Head series in Newfoundland: At Table Point and Table Point Cove.

Discussion.—This species is characterized by its geniculated anterior quarter and the fairly strong rugae. The irregularity and prevailing greater strength of the rugae and their tendency not to be curved or chevron shaped is a distinguishing feature of this species that will separate it from the Virginia shell. Some specimens of *P. ? kindlei* have few or no rugae in the anterior portions. Generally the Virginia shell is completely rugose, although some specimens vary from this generality. The chief distinguishing character between the Canadian and Newfoundland species and *P. virginienensis* is the short and abrupt anterior geniculation toward the brachial valve. This feature is so strong that it seems necessary to question the generic assignment. This assignment is questioned also because the Canadian and Newfoundland specimens occur at a much earlier age (according to present views) than the Appalachian specimens. Furthermore, the interior details of *P. ? kindlei* are yet to be determined. The Table Head brachiopod assemblage is similar in appearance to that of the Botetourt of Virginia and Tennessee, but when their interior features are determined the Table Head forms have generally proved to be generically different from the Appalachian species which they resemble.

PTYCHOGLYPTUS ? MATURA Cooper, new species

Plate 174, C, figures 5, 6

Large for the genus, wider than long, hinge forming the widest part; sides sloping gently toward the middle; anterior margin gently rounded. Posterior half rugose, anterior half marked by costellae of 2 sizes, distant strong costellae in a mat of fine radii, both covering the rugae as well as the anterior nonrugose shell.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity slightly anterior to the middle; anterior profile broadly convex; umbo narrowly convex, the convexity extended anteriorly for about one-third the length; median region moderately swollen, the swelling extending laterally and anteriorly so that the lateral and anterior slopes are short and moderately steep.

Interior brachial valve unknown.

Measurements in mm.—Holotype, length 17.6, midwidth 24.1, hinge width 27.8+, surface length 19.7.

Type.—Holotype: 111061.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile south-east of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its partly rugose and partly nonrugose shell. Furthermore, the rugae are longer than usual in *P. virginienensis*. The important character of this species is its large size, fairly strong convexity, and the fact that about the anterior half is nonrugose. It is possible that specimens of *P. virginienensis* will ultimately be found which will have a more

convex profile and a long nonrugose trail. None have yet been found. Specimens of *P. ? matura* without the trail should be distinguishable from *P. virginensis* by the length of the rugae.

PTYCHOGLYPTUS VIRGINIENSIS Willard

Plate 173, A, figures 1-7; plate 173, B, figures 8-12; plate 174, A, figures 1, 2; plate 174, B, figures 3, 4; plate 174, D, figure 7; plate 174, E, figures 8-17; plate 186, H, figures 32, 33; plate 186, I, figure 34; plate 213, C, figure 22; plate 268, D, figures 12-15

Ptychoglyptus virginensis WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 283, pl. 2, fig. 12, 1928.

Playfairia ? pulchra BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 102, pl. 19, fig. 15, 1926.

Ptychoglyptus pulchrus (Butts) WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 284, 1928.

Shell of moderate size, somewhat semicircular in outline; width about twice the length; hinge forming widest part; cardinal extremities subulate to mucronate. Lateral margins gently convex, oblique; anterior margin broadly rounded. Surface beautifully sculptured, variable, consisting of costellae of 2 sizes and short transverse wrinkles. The largest costellae appear in 3 generations, a median strong costella extending from beak to margin and as many as 9 strong costellae appearing on each side of the median one. Spaces between large costellae occupied by as many as 12 fine costellae. Wrinkles generally confined to the spaces between large costellae except in the cardinal region. Rugae generally short and arcuate posteriorly, chevron shaped.

Pedicle valve very slightly convex in lateral profile, with a narrow but low median fold extending from the umbo to the front margin. Slopes of fold gentle and concave. Lateral extremities flattened. Anterolateral portions of shell somewhat flattened. Beak pointed, prominent, narrow, and only slightly protruding posterior to the posterior margin. Interarea apace line. Interior as described under the generic definition.

Brachial valve gently concave in profile with area of greatest concavity forming a shallow trough from the beak to the margin. Lateral areas bounding sulcus nearly flat. Interarea anacline. Beak obsolete, marked by a pit, so strong is the bending of the interarea. Interior as described under the generic heading.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width |
|-------------------------|--------|-----------------|----------|-------------|
| Holotype | 9.1 | ? | 15.4 | 20.7 |
| Hypotype (98231b) | 8.2 | ? | 11.8 | 15.0 |
| " (111057a) | 8.6 | ? | 13.3 | 16.0+ |
| " (111056a) | 11.2 | 10.6 | 16.2 | 18.8+ |
| " (71475) | 5.6 | ? | 9.0 | 10.4+ |

Types.—Holotype: M.C.Z. 8626; paratype: M.C.Z. 8627; figured hypotypes: 98231a, a-1, b, b-1, 111042a-c, 111052, 111056, 117397, 117398a-f, 123285b, d, e, f; holotype of *P. pulchrus* Butts: 71475; measured hypotypes: 111056a, 111057a.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quad-

rangle; McNutt Quarry, 12 miles southwest of Bland, Burkes Garden (15') Quadrangle; Grayson Farm, 4 miles southwest of Bland, Bland County.

Edinburg formation (Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles due east of Harrisonburg, Harrisonburg (15') Quadrangle.

Botetourt formation in Virginia: At the junction of Virginia Highways 731 and 724, 2 miles northeast of Brownsburg, Lexington (15') Quadrangle.

Edinburg formation (*Cyrtotonotella* zone) in Virginia: In the ravine on the south side of the tracks at the switch $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Effna formation in Tennessee: On the south side of Tennessee Highway 66A, $\frac{1}{2}$ mile northeast of St. Clair, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is one of the most beautifully sculptured brachiopods occurring in Ordovician rocks. It is readily recognized by its strong, often chevron-shaped rugae over which costellae of 2 sizes undulate. This species is variable, but generally the shell is fairly small and is not known to be geniculated. In the latter respect it differs markedly from *P. ? kindlei*. It differs from *P. ? matura* in size, convexity, and the fact that *P. ? matura* has at least half of the anterior part of the shell nonrugose.

The ornamentation of *P. virginiensis* is somewhat variable. The variability is seen chiefly in the rugae which are of different sizes. Some of them are long and extend between 2 distant large costellae, others are short and extend between closely spaced large costellae. No uniformity was noticed by means of which finely rugose and coarsely rugose specimens could be separated into species or subspecies.

Generally the rugae cover the entire shell from beak to anterior and lateral margins. A few specimens, however, are not completely rugose. Such is the type specimen of *P. pulchrus* (Butts). At the same locality numerous specimens were found which conform closely to *P. virginiensis* and others which are intermediate in character between the two. It was thought best, therefore, to submerge Butts' species in the synonymy of *P. virginiensis*.

PTYCHOLYPTUS ? sp. 1

Three specimens from the Mystic conglomerate in Quebec on Range 6, Lot 21, indicate a species quite unlike *P. ? kindlei*. This is a finely and completely rugose species. It is wider than long and with a wide hinge. The brachial valve only is known, and it is moderately and evenly concave. The valve is not geniculated at the anterior.

Measurements in mm.—123299a, length 9.1, midwidth 15.3, hinge width 18.4.

Described specimens.—123299a-c.

Horizon and locality.—Mystic conglomerate in Quebec, Canada: On Range 6, Lot 21, 2.6 miles due north and $\frac{1}{2}$ mile east of Mystic, Stanbridge Township.

Superfamily STROPHOMENACEA Schuchert, 1896

Usually with thin visceral cavity; pseudodeltidium present; foramen apical when present; cardinal process double shafted; chilidium present.

Family LEPTAENIDAE Cooper, new family

Compressed to faintly lenticular Strophomenacea with large apical foramen.

Genus LEPTAENA Dalman, 1828

Leptaena DALMAN, K. Svenska Vet.-Akad. Handl. for 1827, pp. 93, 94, 1828.

LEPTAENA ORDOVICICA Cooper, new species

Plate 208, B, figures 19-21; plate 212, C, figure 32; plate 228, B, figures 8-18

Leptaena tenuistriata Sowerby var. BASSLER, Cambrian and Ordovician: Maryland Geol. Surv., p. 260, pl. 49, fig. 2, 1919.

Shell of about medium size for the genus, hinge forming the greatest width, the cardinal extremities angular and alate. Length equal to about three-fourths the width at the middle. Lateral margins excavate just anterior to the cardinal extremities, narrowly rounded at the anterolateral extremities and broadly rounded at the front margin. Surface unequally costellate, 1 to 2 of the smaller costellae alternating with the stronger ones. At the front margin 18 costellae occupy a space of 5 mm. Body with thin concentric undulations.

Pedicle valve with visceral region or body depressed below (brachiad) the rim marking place of geniculation; umbonal region swollen, the swelling continued anteriorly as a low fold nearly to the rim of geniculation. Areas surrounding swollen fold and in front of it concave with gentle slopes from the umbo. Geniculated rim strong, located 12 mm. anterior to the beak, narrowly rounded in section, sharply bent at the anterolateral extremities of the body and extending with a broad curve convex outward to the anterior side of the ear. Angle of geniculation about 90°. Geniculated part nearly flat in profile, descending steeply to the anterior margin but less steeply around the sides to the ears. Interarea short, delthyrium wide, partially covered by a short pseudodeltidium.

Brachial valve closely fitting the pedicle valve; umbo concave with concavity extended nearly to middle; between concave area and point of geniculation valve is gently convex; geniculated area marked by a deep groove. Interarea short.

Interior of pedicle valve with subcircular to subflabellate muscle field; diductor scars large, semiflabellate; teeth strong, dental plates thick and flaring; pedicle callist small, apical. Entire visceral region tuberculate. Interior of brachial valve with short, low, median ridge, somewhat thickened adductor field and tuberculate surface.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.0 | ? | 20.3 | 23.0 | ? |
| Paratype (117666).... | 15.4 | ? | 19.6 | 20.3 | ? |
| " (117664a)... | 10.4 | ? | 16.4 | 13.6 | ? |
| " (117667).... | ? | 13.1 | 20.5 | 24.0 | ? |

Types.—Holotype: 117669a; figured paratypes: 117664a, 117665, 117666, 117667, 117668, 117669b, 117670a-c.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle; $\frac{1}{2}$ mile east of Strasburg, Strasburg (15') Quadrangle; just west of the junction of Virginia Highways 617=910, and 777, $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle.

Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia Highway 617=910, 0.15 mile north of Green Mount Church, $\frac{1}{2}$ mile northwest of Linville Station, Broadway (15') Quadrangle.

Martinsburg formation (*Sinuities* bed) in Pennsylvania: 1 mile south of St. Thomas, Mercersburg (15') Quadrangle; Carlisle, Carlisle (15') Quadrangle.

Rodman formation in Pennsylvania: At Bellefonte, Bellefonte (15') Quadrangle.

Salona formation in Pennsylvania: At Salona, on Fishing Creek, Lock Haven (15') Quadrangle.

Rysedorf conglomerate in New York: Near Albany.

Carters formation in Alabama: 5 feet below the top of the limestone in the quarry 0.3 mile north of Gate City, Birmingham Special (15') Quadrangle.

Edinburg formation (*Cyrtonotella* zone just above the siltstone) in Virginia: 200 yards east of U. S. Highway 11, on Hiatt Run, 3 miles northeast of Winchester, Winchester (15') Quadrangle.

Dark shale under Eureka quartzite in Nevada: Under 2 knobs of Eureka quartzite, north side canyon, 3.1 miles N. 32° E. of Blair (Segura) Ranch, Antelope Mountains, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by the discontinuous character of the concentric wrinkles, the swollen umbonal region of the pedicle valve, the elevated rim around the place of geniculation, the nearly right-angled geniculation and long trial. This species differs from the *L. tenuistriata* Sowerby identified by Foerste from the Saltillo formation in west Tennessee in having a different outline, the Appalachian shells being more quadrate. The Saltillo shell does not have the elevated rim at the place of geniculation nor the swollen umbonal region. No other American species of true *Leptaena* are known to which this species may be compared.

Leptaena ordovicica is a rare species in most localities of the Oranda formation. It is locally abundant, however, as at the Linville locality.

Two specimens from the *Cyrtonotella* zone near the base of the Edinburg formation are referred to this species. These specimens are smaller than is usual in the Oranda forms, but the essential specific characters of *L. ordovicica* are present. These are the earliest specimens of true *Leptaena* yet found in North America.

HESPERINIA Cooper, new genus(Greek *hespera*, west)

Small, subrectangular shells with the hinge equal to or wider than the mid-width; plano- to slightly concavo-convex; surface multicostellate. Foramen not seen. Shell substance coarsely pseudopunctate.

Pedicle valve with long interarea, wide delthyrium covered by a pseudodeltidium. Teeth large; dental plates oblique, moderately long. Musculature not known.

Brachial interior with moderately strong and erect cardinal process consisting of 2 lobes and suggesting that of *Leptaena*. Brachiophores, flat blades, obliquely situated on each side of the cardinal process and supported by shell substance as in the Strophomenidae; adductor field large; subperipheral rim well developed and channeled by pallial trunks.

Genotype.—*Hesperinia kirki* Cooper, new species.

Discussion.—The external appearance of this little genus is very close to that of *Pomatotrema* of the high Canadian Period. The interior details, however, are totally unlike in the two genera because *Pomatotrema* has a simple cardinal process whereas *Hesperinia* has a bilobed or leptaenoid cardinal process. Indeed, this species suggests an early leptaenoid.

Affinities with *Leptaena* occur also in the configuration of the valves, the pseudodeltidium, the subperipheral rim and cardinal process of the brachial valve interior. The shells differ from *Leptaena* or *Dactylogonia* in interior details of the brachial valves, *Hesperinia* lacking the adductor ridges, the thickened notothyrial platform, and thick but short median ridge. These features also distinguish this genus from *Goniotrema* which is also a Pogonip genus.

HESPERINIA KIRKI Cooper, new species

Plate 213, E, figure 25; plate 229, C, figures 9-15

Shells small, attaining a width of about $\frac{1}{2}$ inch; subrectangular in outline; sides gently rounded; anterior margin broadly rounded; cardinal extremities nearly a right angle; hinge equal to the midwidth. Surface finely costellate, costellae numbering about 5 to the millimeter at the anterior margin.

Pedicle valve gently convex in lateral profile and with the maximum convexity in the posterior two-thirds; anterior third somewhat abruptly bent toward the brachial valve. Anterior profile broadly and fairly strongly convex. Umbonal and median regions swollen; lateral slopes long and only moderately steep; anterior slope shorter and steeper than the lateral slopes. Interarea moderately long, apsacline; pseudodeltidium short, convex.

Brachial valve nearly flat in lateral and anterior profile; anterior margin gently curved in the direction of the brachial valve. Interior with narrow marginal thickening.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 5.9 | 5.2 | 7.3 | 7.6 | 1.4 ? | 1.8 |
| Paratype (117625) | ? | 7.3 | 10.7 | 10.6 | ? | ? |

Types.—Holotype: 117626a; figured paratypes: 117625, 117626c, 117627a; unfigured paratypes: 117626b,d, 117627b-f.

Horizon and locality.—Tank Hill formation in Nevada: In the ridge just east of Monument Canyon, Pioche (1°) Quadrangle; north end of the west side of the Ely Spring Range, Highland (15') Quadrangle.

Upper Pogonip group in Nevada: In White Pine Range, Hamilton.

Discussion.—No other species of this genus is now known to which this one can be compared.

TERATELASMA Cooper, new genus

(Greek *teras*, marvel; *elasma*, plate)

Shells small, attaining a length and width of about $\frac{1}{4}$ inch; subquadrate in outline; gently biconvex in lateral profile; anterior commissure narrowly sulcate; surface finely multicostellate. Pseudopunctate.

Pedicle interior with short, stout flaring dental plates; diductor-adjustor scar widely divergent, tear-shaped. Median region narrowly and deeply sulcate.

Brachial interior with wide and moderately deep notothyrial cavity; cardinal process bilobed; sockets moderately deep, small, bounded by small, short brachio-phores; notothyrial cavity bounded on each side by a plate inclined to the valve floor, lying just anterior to the brachio-phore and extending to about the middle; median septum club-shaped, originating just anterior to the middle of the notothyrial cavity and extending to the front margin; median septum expanded and elevated at its point of origin in the notothyrial cavity.

Genotype.—*Teratelasma neumani* Cooper, new species.

Discussion.—The interior details of this genus indicate a relationship to *Dactylogonia* and the leptaenoids. The exterior is misleading because *Teratelasma* suggests a finely costellate orthid rather than a leptaenoid. The relationship to *Dactylogonia* is clear enough when the shell is examined in detail. Although orthoid in appearance, the shell substance of *Teratelasma* is pseudopunctate. Furthermore, the genus has a leptaenoid foramen which can be seen as a small plug on the steinkern shown on plate 225, B, figures 5, 6, 7. Internally the relationship to *Dactylogonia* and the leptaenoids is clear in the presence of the bilobed cardinal process which shows as two pits in figure 5 referred to above.

The interior details of this genus are as distinctive as the exterior characters, especially in the brachial valve. The cardinalia are characterized by the bilobed cardinal process which is small and delicate. The brachial processes are flat, oblique blades on each side of the cardinal process. The adductor field is marked by ridges similar to those in *Dactylogonia* but somewhat differently developed. The posterolateral adductor ridge is small and not well formed. The inner 2 ridges are extravagantly developed and may appear as long hollow processes. Figure 7 of plate 225, B, shows 2 holes slightly posterior to the middle that represent the tubes. The tubular plates can also be seen in figures 10 and 11.

The most striking feature of this peculiar genus is the median septum which is unlike that of any other leptaenoid. This originates just inside the space between the anterior ends of the adductor blades and extends anteriorly nearly to the front margin. At its posterior end the septum is stout and descends into the adductor field as a sort of muscle platform. Anteriorly the septum is so strongly elevated that it divides that part of the valve into 2 chambers. The trace of this high-bladed septum can be seen on the pedicle side of the steinkern figured on plate 225, B, figure 7. An impression of the blade is shown in figure 18 of the same plate.

Teratelasma differs from *Dactylogonia* in its exterior form which is not leptaenoid and in the arrangement of the adductor processes and the presence of the high median septum.

TERATELASMA NEUMANI Cooper, new species

Plate 225, B, figures 5-23

Shell small, subquadrate in outline, with the hinge equal to the greatest width; cardinal extremities nearly a right angle; sides nearly straight; anterior margin somewhat narrowly rounded; anterior commissure narrowly sulcate; surface finely costellate, about 8 crowded in the space of 1 mm.

Pedicle valve nearly flat in lateral profile; narrowly keeled medianly and with the sides somewhat concave in anterior profile; umbo narrowly swollen, the swelling continued anteriorly to form a narrow, subcarinate fold that extends to the front margin; sides of fold steep; flanks bounding fold flattened to concave; interarea moderately long, apsacline.

Brachial valve gently convex to nearly flat in lateral profile; anterior profile broadly and very gently convex and with the median region narrowly depressed; sulcus originating at the umbo and extending to the front margin where it occupies about one-quarter the width; flanks bounding sulcus gently convex.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--|--------|-----------------|----------|-------------|-----------|
| Paratype (pedicle valve 117938f) | 6.8 | ? | 9.0 | 10.0 ? | ? |
| " (brachial valve 117938j) | ? | 5.3 | 7.9 ? | 8.6 | ? |

Types.—Holotype: 117938d; figured paratypes: 117938c,e,g,j,k,l-o,q; unfigured paratypes: 117938a,b,h,i,p.

Horizon and locality.—Sevier formation (Benbolt equivalent) in Tennessee: 0.53 mile east-southeast of Old Kagley Church, Binfield (T.V.A. 139-NE) Quadrangle.

Discussion.—No other species of this genus is known to which this one may be compared. The only known specimens are from the Sevier formation at the Benbolt level.

DACTYLOGONIA Ulrich and Cooper, 1942

Dactylogonia ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 623, 1942.

Shell of moderate size often attaining a little more than an inch in width, usually wider than long, with the hinge forming the widest part; lateral margins

sloping inward, anterior margin broadly rounded. Concavo-convex in lateral profile with both valves geniculated strongly in the direction of the brachial valve. Surface finely costellate, usually without concentric wrinkles.

Pedicle valve with long palintrope, covered delthyrium, strongly convex pseudodeltidium and apical foramen. Muscle field moderately large with fairly long and wide diductor scars. Adjustor impressions present and adductors attached to a low median elevation. Internal surface tuberculate.

Brachial valve with small cardinal process composed of 2 short-shafted pieces with myophore surfaces each receiving a pair of muscles; median ridge low or obsolete; brachial processes flat blades supported by the callus swelling of the notothyrial and muscle regions; adductor field fairly small, marked by 4 blade-like plates arising from the floor, the smaller 2 between anterior and posterior adductor scars and the larger 2 on the inside of the anterior scars. Line of geniculation marked by a low, thickened ridge; entire inner surface tuberculate.

Genotype.—*Dactylogonia geniculata* Ulrich and Cooper, Journ. Paleont., vol. 16, No. 5, p. 624, pl. 90, figs. 19-23, 1942.

Discussion.—*Dactylogonia* differs from *Leptaena* in the absence of concentric wrinkles in the visceral portion, but more importantly in the presence in the brachial valve of the bladelike ridges arising from the floor between the muscle scars and in the small median ridge. Members of this genus occur in the Chazy (Crown Point and Valcour) formations of New York and in several formations of the Southern Appalachians of Tennessee and Virginia, and in the Bromide formation of Oklahoma.

DACTYLOGONIA ALTERNATA Cooper, new species

Plate 218, D, figures 11-14; plate 218, G, figures 22-30

Shell of about medium size for the genus, wider than long and with the hinge forming the widest part; sides gently rounded; anterior margin broadly rounded; geniculation taking place about 8 mm. anterior to the beak; angle of geniculation about 100°. Surface marked by fine and coarse costellae, about 5 or 6 of the former occupying a space of 5 mm. at the front margin and up to 7 fine costellae between the stronger ones.

Pedicle valve with visceral region flat to slightly concave in lateral profile; geniculated part narrowly rounded; trail short and gently convex in profile; foramen moderately large; interarea long; pseudodeltidium large.

Brachial valve with visceral part nearly flat to faintly convex; trail short and fairly abruptly bent.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Thickness | Surface length | Length of trail |
|------------------------|--------|-----------------|-----------|-------------|-----------|----------------|-----------------|
| Holotype | 11.8 | 10.0 | 15.4 | 13.5+ | 4.6 | 16.0 | 7.0 |
| Paratype (117581a).... | 12.5 | ? | 17.1 | 18.0 | ? | 16.0 | 7.0 |
| " (117581b).... | 10.3 | 8.8 | 14.0 | 14.0 | 2.2 | 11.5 | 3.0 |
| " (117581e).... | 10.6 | 9.5 | 16.4 | 16.9 | 4.1 | 14.0+ | 5.0+ |

Types.—Holotype: 117581c; figured paratypes: 117581a,b,d,e, 117582a,b.

Horizon and locality.—Lenoir formation (reefy calcarenite beds under the Mosheim limestone) in Tennessee: On the southwest side of the cemetery behind the Friends Church, northwest edge of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Lenoir formation (granular beds above the Mosheim limestone) in Tennessee: At Bluff City, Bluff City (T.V.A. 198-NE) Quadrangle; south of Friends Church, northwest side of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Tumbez formation in Virginia: In a small quarry on the south side of U. S. Highway 11, 3 miles southwest of Marion, Marion (T.V.A. 218-SE) Quadrangle.

Discussion.—This species has generally been mistaken in the Southern Appalachians for *D. incrassata* (Hall). It is characterized by fairly large size for the genus and fairly strong geniculation. This species differs from *D. incrassata* in having a much larger size, in having a longer visceral disk region, somewhat less strong geniculation and a shorter trail. It differs strongly from *D. geniculata* in having a less rectangular outline, stronger costellae, and a less strongly geniculated trail.

DACTYLOGONIA CONCENTRICA Cooper, new species

Plate 216, B, figures 5-7

Small, semielliptical in outline, hinge about equal in width to the width of the valve at the middle; cardinal extremities approximately a right angle; sides gently rounded; anterior margin broadly rounded. Surface marked by about 11 prominent thin, rounded costellae separating groups of very fine elevated costellae that are crossed by fine elevated concentric lines of about the same strength as the fine costellae producing a beaded effect. Ornamentation of brachial valve showing a slightly stronger development of the concentric lines.

Body of pedicle valve gently convex in lateral profile and very gently convex in anterior profile; geniculation of the pedicle valve taking place slightly less than 8 mm. anterior to the beak; angle of geniculation about 100°. Geniculated area short. Palintrope broad; interarea long and flat; pseudodeltidium strongly convex. Apical foramen small.

Brachial valve gently concave with the greatest concavity appearing as a pit just anterior to the umbo. Anterior geniculation slight, resulting in a valve of nearly uniformly gentle concavity. When the shell is moistened the sutures of the adductor plates with the floor of the valve are visible.

Measurements in mm.—Holotype, length 8.5, surface length 10, body length 8, length of gen. area 2, width 11.7, hinge width 11, thickness 3.6.

Type.—Holotype: 117583.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 2 miles northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle.

Discussion.—This is a small species characterized by subrectangular outline,

flattish brachial valve and subdued ornamentation in which the concentric fila are prominent. It is not quite like any other species so far described. It differs from *D. geniculata* in the strength of the concentric elements of the ornamentation, the gentle convexity of the pedicle valve, and the short trail.

DACTYLOGONIA EXTENSA Cooper, new species

Plate 219, B, figures 2-5

Leptaena incrassata TWENHOFEL and WHITING (not Hall), Geol. Soc. Amer. Special Pap. 11, p. 50, pl. 7, figs. 17, 18, 1938.

Shell of about medium size for the genus, with the widest part slightly anterior to the hinge; lateral margins sloping inward strongly; anterior margin broadly rounded; ornamentation consisting of groups of 5 to 7 fine costellae bounded by stronger costellae.

Pedicle valve with posterior half of shell concave to flat in lateral profile, the concavity located just anterior to the umbo; flanks of posterior half slightly concave but rising to the place of geniculation about 7.5 mm. anterior to the beak. Angle of geniculation variable; geniculated portion long and convex, most convex at and just anterior to point of flexure; length of geniculate portion greater than the length of the body part of the shell. Anterior slope steep, decreasing posterolaterally to the cardinal extremities where it becomes considerably flattened. Palintrope unusually long, apsacline.

Brachial valve with slightly convex body part and abruptly bent geniculated portion.

Measurements in mm.—Holotype, length 13, width 19, hinge width 18, surface length 18, body part surface length 7.5, surface length of trail 10.5.

Types.—Holotype: 117584b; figured paratype: 117584a.

Horizon and locality.—Mingan formation (lower third), Bald Island, Mingan Group, St. Lawrence River.

Discussion.—This species is characterized by its long trail and the rounded area of geniculation. It is most like some extreme examples of *D. incrassata* but the angle of geniculation is greater and the trail longer. The Mingan form does not have the geniculated part so narrowly rounded even though tangents to the visceral region and the trail intersect in an acute angle. The angle is about 75° in *D. extensa* but only 55° in *D. incrassata*. The interarea of *D. extensa* is much longer and the pseudodeltidium larger than in *D. incrassata* which has only a short interarea.

DACTYLOGONIA GENICULATA Ulrich and Cooper

Plate 216, D, figures 14-30; plate 217, M, figures 38, 39; plate 218, B, figures 4-7; plate 219, E, figure 11; plate 219, F, figures 12, 13

Dactylogonia geniculata ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 624, pl. 90, figs. 19-23, 1942.

Shell wider than long with acute cardinal extremities; profile concavo-convex; lateral margins sloping medially; anterior margin broadly convex to subtruncate.

Surface covered by closely crowded costellae of unequal size, 5 to 9 of the smaller costellae arranged into groups by the scattered larger ones.

Pedicle valve with the posterior 9 mm. nearly flat but the anterior narrowly convex; geniculation takes place at about 9 mm. anterior to the beak and the angle of geniculation is about 95° . Beak erect, the umbo inconspicuous but slightly swollen. Geniculated part narrowly convex; front slope slightly convex in profile and steep.

Umbo of brachial valve forming a round hollow anterior to the beak; body of valve slightly concave but flattened somewhat at the cardinal extremities. Geniculated part fitting closely against the trail of the pedicle valve and having practically the same contour as that valve.

Interior of pedicle valve with muscle field not quite extending to the middle, moderately impressed; adductor ridge low. Brachial valve with short median septum situated between the lobes of the cardinal process; adductor blades strongly developed; ridge at front of visceral area slightly elevated, moderately thick.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length |
|-----------------------|--------|-----------------|----------|-------------|-----------|----------------|
| Holotype | 11.1 | 9.8 | 15.0 | 16+ | 3.0 | 15.0 |
| Paratype (108202e)... | 10.2 | 9.8 | 14.7 | 16+ | 2.9 | 14.5 |
| " (108202f) ... | 11.1 | 10.2 | 15.8 | ? | 2.3 | 14.0 |

Types.—Holotype: 108202a; paratypes: 108202b-g; figured hypotypes: 117585b,c,f,h, 117586a, 117587, 117588a.

Horizon and locality.—Arline formation in Tennessee: Along old wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; $\frac{1}{4}$ mile south of McMullens, Meadow (T.V.A. 139-NW) Quadrangle.

Arline formation in Virginia: Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Little Oak formation in Alabama: Junction of Bailey Gap and main roads, $1\frac{3}{4}$ miles northeast of Newhope Church, Cahaba Valley, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., Vandiver (15') Quadrangle.

Discussion.—This species can be recognized by the similarity of its outline and profile to examples of *Leptaena*. The outline is nearly rectangular and the anterior geniculation is abrupt. No other described species except *D. prona* and *D. transversa*, is quite like it in these respects. *D. prona* (Willard) is suggestive but that species is much larger and the trail is marked by a distinct sulcus. *Dactylogonia transversa* is strongly rectangular in outline and is abruptly geniculate, but it is a larger and proportionately wider shell than *D. geniculata*.

DACTYLOGONIA INCRASSATA (Hall)

Plate 219, I, figures 16-23; plate 219, J, figures 24-27; plate 220, B, figures 6-8; plate 226, C, figures 5-9

Leptaena incrassata HALL, Pal. New York, vol. 1, p. 19, pl. 4 bis, figs. 2a-d, 1847.—RAYMOND, Ann. Carnegie Mus., vol. 7, No. 2, p. 230, pl. 34, figs. 32-37, 1911.

Shell fairly large for the genus, wider than long, with the hinge width almost twice the length; cardinal extremities alate; strongly geniculate; angle of genicu-

lation variable; surface marked by strong and fine costellae, about 5 of the latter in 5 mm. at the front margin and about 7 fine costellae separating the larger ones. Fine costellae strongly cancellated by fine concentric lines.

Pedicle valve with variable lateral profile, the visceral portion varying from flat to gently convex, the geniculated part from narrowly convex. Trail nearly flat to gently convex and varying in angle of geniculation from 60° to 100° . Geniculation occurring 6 or 7 mm. anterior to the beak. Geniculated part narrowly to roundly convex depending on angle of geniculation. Umbonal and median regions somewhat swollen; flanks of visceral part somewhat depressed. Interarea moderately long; pseudodeltidium large and convex.

Brachial valve with visceral part gently concave, with the median region the deepest part and the flanks somewhat flattened. Trail moderately long, slightly concave; adductor plates strongly developed.

Measurements in mm.—

| | Length | Brachial length | Mid-width | Hinge width | Thickness | Surface length | Trail length |
|--------------------------|--------|-----------------|-----------|-------------|-----------|----------------|--------------|
| Hypotype (117589a)..... | 10.8 | 8.8 | 16.4 | 15.6+ | 4.1 | 18.0 | 9.0 |
| " (117589b)..... | 10.8 | 9.1 | 14.6 | ? | 4.2 | 16.0 | 8.0 |
| " (Carnegie Mus. 5446) . | 11.7 | ? | 16.0 | 21.7 | ? | 15.0 | 7.0 |

Types.—Figured hypotypes: Carnegie Mus. 5446; A.M.N.H. 25049/1,2,3; U.S.N.M. 117589a-c, 117590a, 117593a,b.

Horizon and locality.—Crown Point formation in New York: At Sloop Bay, Valcour Island, Lake Champlain, Plattsburg (15') Quadrangle.

Same formation in Vermont: On Isle La Motte, Rouses Point (15') Quadrangle; on a small peninsula of the west shore of Providence Island, Plattsburg (15') Quadrangle; Fort Cassin, Port Henry (15') Quadrangle.

Discussion.—This species is without doubt a fairly variable one, but in spite of that it does not seem to occur in the Southern Appalachians. *Dactylogonia alternata* has been mistaken for it but that species is larger and less strongly geniculated. *Dactylogonia incrassata* has been confused on Mingan Island with a somewhat more robust form having a more elongate interarea and longer trail. The two species of *Dactylogonia* now known from Oklahoma are quite unlike *D. incrassata* because they are only slightly geniculated. *Dactylogonia marmorata* is suggestive but that species has fairly prominent wrinkles which distinguish it at once from the New York species.

DACTYLOGONIA MAGNA Cooper, new species

Plate 194, E, figures 28-30; plate 220, C, figures 9-17

Shell large for the genus, slightly wider than long with the hinge not quite equal to the shell width at the middle; sides and anterior margin gently rounded; point of geniculation about 12 mm. anterior to the beak; angle of geniculation about 95° . Ornamentation consisting of a few strong costellae in a field of finer ones; 3 strong costellae to 5 mm. at the front margin; strong costellae separated by as many as 10 of the finer kind; fine costellae cancellated by fine concentric lines. Posterior margin with short vertical wrinkles.

Pedicle valve roundly angulated at about the middle in lateral profile; posterior or visceral portion nearly flat in lateral profile; geniculate portion somewhat broadly rounded; trail long and gently convex in profile. Umbo somewhat narrowly rounded; median portion of visceral region convex but flanks somewhat depressed. Posterior margin irregularly wrinkled. Interarea long; pseudodeltidium thick and convex. Muscle area small.

Brachial valve deeply concave, most concave in the median region where the valve geniculates; umbo and median region of the visceral part sulcate; flanks bounding sulcus flattened. Posterior margin wrinkled.

Measurements in mm.—Holotype, length 21.0, brachial length 18.3, midwidth 24.9, hinge width ?, thickness 3.1, surface length 28.0, trail length 14.0.

Types.—Holotype: 117591a; figured paratypes: 117591b,d, 117592; unfigured paratypes: 117591c.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: 0.4 mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SW) Quadrangle.

Discussion.—*Dactylogonia magna* is an unusually large species for this genus which, besides its size, is characterized by an unusually long trail and a nearly square outline. It can only be compared to the larger species of the genus such as *D. obsoleta* (Butts) and *D. obtusa*. It differs from the former in larger size, square outline, longer trail, and more deeply concave brachial valve. From the latter it differs in its larger size, square outline, and the long, rounded trail.

DACTYLOGONIA MAGNIFICA Cooper, new species

Plate 225, A figures 1-4

Shell of about medium size for the genus, thin shelled, generally wider than long and with the hinge forming the widest part; cardinal extremities acute; sides sloping obliquely toward the middle. Surface marked by strong costellae, 2 or 3 in 5 mm. at the front which separate bands of closely crowded and beautifully cancellated costellae; fine costellae numbering about 7 to the millimeter at the front margin.

Pedicle valve very gently convex in lateral profile but somewhat angulated in the front fifth; anterior profile broadly and gently convex and somewhat carinated in the middle; umbonal region slightly inflated, the swelling continued anteriorly to the place of geniculation at the front as a low but poorly defined fold; lateral slopes long and sloping gently to the sides. Foramen large, encroaching on the umbo; interior with large and flabellate muscle area.

Brachial valve nearly flat to gently concave in profile and the anterior quarter bent in the direction of the brachial valve at a broad angle. Umbonal region sulcate. Interior with strongly developed and closely crowded adductor ridges.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 8.5 | ? | 11.4 | 12.9 | ? |
| Paratype (brachial valve 117942c) .. | ? | 8.7 | 12.0 | 12.8 | ? |

Types.—Holotype: 117942a; figured paratypes: 117942c,d; unfigured paratype: 117942b.

Horizon and locality.—Lower Ward Cove formation in Tennessee: $\frac{3}{4}$ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle.

Discussion.—This species is characterized by its angular lateral extremities, short geniculated area and distant costellae in a mat of fine cancellated costellae. This species is most like *D. incrassata* (Hall) of the New York Chazyan but is more distantly and more delicately ornamented. It is less strongly geniculated and less square in the cardinal extremities than *D. geniculata*, and differently ornamented.

DACTYLOGONIA MARMORATA Cooper, new species

Plate 217, F, figures 11-15

Shell small for the genus, wider than long and with the hinge forming the widest part; sides gently rounded; anterior margin broadly rounded. Surface marked by a mat of fine costellae cancellated by fine concentric lines; a few larger costellae 5 or 6 in number are present. More or less prominent concentric wrinkles mark the visceral region.

Pedicle valve with visceral region extending for 5 to 7 mm. from the beak, gently convex in lateral profile; angle of geniculation variable, usually near 95° ; trail variable, usually fairly long and steep.

Visceral region of brachial valve gently concave; umbo concave; deepest at place of geniculation; trail not so long as that of the pedicle valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Trail length |
|-----------------------|--------|-----------------|----------|-------------|-----------|----------------|--------------|
| Holotype | 8.9 | ? | 11.8 | 12.9 | ? | 9.5 | 1.5 |
| Paratype (123265a)... | 6.9 | ? | 10.6 | 12.1 | ? | 7.5 | 2.0 |
| " (123265c)... | ? | 8.7 | 13.5 | 16.7 | ? | 10.0 | 2.0 |
| " (123265d)... | 8.4 | ? | 11.9 | 12.7 | ? | 11.0 | 3.0 |

Types.—Holotype: 123265b; figured paratypes: 123265a,c,d; unfigured paratype: 123265e.

Horizon and locality.—Murat formation in Virginia: 2 miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This is a species of moderate size somewhat resembling *D. incrassata* or *D. extensa* in form. It differs from both of them in having moderately strong but irregular wrinkles on the visceral disk area. *Dactylogonia palustris* is also a somewhat wrinkled form but differs in its smaller size, more regular outline, shorter trail, and smaller visceral disk region.

DACTYLOGONIA OBSOLETA (Butts)

Plate 217, K, figures 32-34

Rafinesquina obsoleta BUTTS, Alabama Geol. Surv., Special Rep. 14, pl. 26, figs. 29, 30, 1926.

Only two specimens of this species are known that preserve the outline and profile of the shell. As both are coarsely silicified, description of details of the

exterior will have to await the discovery of more favorably preserved specimens. Information on the interior is also lacking except for the cardinal process. The holotype is large for the genus, with the hinge forming the widest part and the lateral margins sloping gently toward the middle. The anterior margin is broadly rounded. The surface shows distant costellae and faint traces of finer ones between the larger ones.

The pedicle valve is strongly convex with the greatest convexity located slightly anterior to the middle; inasmuch as the body of the shell is not clearly marked from the geniculated portion by an abrupt change of curvature, it is difficult to place the position of geniculation, but it appears to be about 8 to 10 mm. anterior to the beak. The body of the shell is gently convex in profile and has a slightly swollen umbonal region. The anterior sloping part or trail is moderately steep, with the steepest parts toward the anterolateral extremities. Angle of geniculation 120° . Interarea short, apsacline.

The brachial valve is strongly geniculated at an angle of about 130° about 10 mm. anterior to the beak; the deflected part is steep and makes a rim about 6 mm. wide around the body of the shell which is flat to slightly concave.

Measurements in mm.—Holotype, length 18.3, brachial length 13.2, width 23.8, hinge width 22.7, thickness 5.0, surface length 22.5.

Type.—Holotype: 71505.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile north of Pelham, Bessemer Iron District (15') Quadrangle; junction Bailey Gap and Cahaba Valley roads, $1\frac{3}{4}$ miles northeast of Newhope Church, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., Vandiver (15') Quadrangle.

Discussion.—This species is characterized by large size, wide hinge, strong convexity of the pedicle valve, and gentle concavity of the brachial valve. This species suggests *D. obtusa* but differs in angle of geniculation and is larger, less deep, and with more oblique sides.

DACTYLOGONIA OBTUSA Cooper, new species

Plate 216, C, figures 8-13; plate 217, L, figures 35-37; plate 220, A, figures 1-5

Shell large, variable, wider than long with the hinge forming the widest part; lateral margins sloping moderately toward the middle or slightly rounded; anterior margin broadly rounded. Surface costellate, costellae rounded and separated by spaces narrower than the costellae; on the pedicle valve costellae alternate in size, 1 or 2 smaller ones alternating with the larger ones, but on the brachial valve the costellae are more uniform in appearance and more crowded with less differentiation between the larger and smaller ones.

Pedicle valve geniculating about 11 mm. anterior to the beak; angle of geniculation obtuse, about 95 to 100° ; visceral portion moderately convex, umbo and beak slightly swollen; a low, indistinct median fold extends anteriorly for about a quarter the length but in some specimens is distinguishable for the length of the body of the shell. Median part of shell body slightly swollen with gentle slopes to the margins. Geniculated part or trail convex in profile, and with steep-

est slopes at the anterior. Palintrope and pseudodeltidium short; apical foramen smaller than usual in the genus.

Brachial valve fitting closely into the pedicle valve and with concave umbonal region; valve flattened slightly in the vicinity of the cardinal extremities. Most concave in the midregion, less so laterally of the middle.

Pedicle valve with small wide teeth that have deep fossettes, dental plates nearly obsolete; muscle area slightly wider than long; diductor scars large, adductor field narrowly elliptical, periphery of muscle field slightly thickened and surrounding shell surface tuberculate.

Brachial valve with notothyrial platform thickened and bearing 2 short shafted processes with flattened myophore surfaces. Brachial processes flat, short, supported by the notothyrial platform. Median ridge nearly obsolete. Posterior adductor scars the larger; anterior adductor processes long and convex inward. Entire inner surface of visceral portion strongly tuberculate.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness | Surface length |
|----------------------|--------|-----------------|-------|-------------|-----------|----------------|
| Holotype | 16.5 | 14.5 | 18.3 | 18 + | 3.4 | 20.5 |
| Paratype (117595) .. | 17.9 | 13.8 | 22.2 | 20.6 | 4.8 | 22 + |

Types.—Holotype: 117594i; figured paratypes: 117594c,d,h, 117595, 117596; unfigured paratypes: 117594a,b,e-g.

Horizon and locality.—Lincolnshire formation (2-foot layer on marble) in Tennessee: In Clinch Valley at Shiloh Church, near center of the northwest subquad. of Pressmans Home (T.V.A. 171-NE) Quadrangle.

Same formation in Virginia: At Marcem Quarry, 2 miles west of Gate City, Gate City (T.V.A. 188-NE) Quadrangle.

Arline formation in Virginia: In Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species is a moderately large one characterized by a subrectangular to subquadrate outline, gently convex visceral region, moderately strong geniculation, and moderately deep brachial valve. It differs from *D. obtusa* in not having a wide hinge, in the more narrowly rounded anterior, the less deep brachial valve, and a less obtuse angle of geniculation. It differs from *D. prona* which also occurs in the Lincolnshire formation in its less abrupt geniculation and the longer and more gently inclined trail.

DACTYLOGONIA PALUSTRIS (Willard)

Leptaena palustris WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 278, pl. 3, fig. 14, 1928.

Type.—Holotype: M.C.Z. 8619.

Horizon and locality.—Holston limestone = Farragut formation in Tennessee: At Concord, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This is a small species characterized by fairly regular form, moderate geniculation, and a moderately but irregularly wrinkled visceral region. No specimens in the National Collection can be identified with this species.

DACTYLOGONIA PARVA Cooper, new species

Plate 218, A, figures 1-3

Small for the genus, subtrapezoidal in outline and with the hinge forming the widest part. Sides gently rounded and oblique; anterior margin broadly rounded; surface marked by strong and fine costellae, the former not well developed; concentric wavy lines cancellate the fine costellae and generally dominate the ornamentation. Visceral region marked by discontinuous concentric wrinkles especially near the place of geniculation.

Pedicle valve geniculating about 5 mm. anterior to the beak; angle of geniculation abrupt, approximately 90° . Visceral region marked by a poorly defined, low median fold; flanks bounding fold concave; anterior of visceral region marked by a more or less prominent concentric fold. Trail long, gently convex in lateral profile.

Brachial valve with visceral region gently concave; umbonal region concave; lateral areas of visceral region somewhat flattened. Trail abruptly geniculated.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Trail length |
|---------------------|--------|-----------------|----------|-------------|-----------|----------------|--------------|
| Holotype | 6.6 | ? | 8.1 | 9.6 | ? | 8.5 | 4.5 |
| Paratype (117597c). | 6.5 | 5.2 | 8.7 | 9.8 | 1.6 | 7.5 | 2.0+ |

Types.—Holotype: 117597a; unfigured paratypes: 117597b-e.

Horizon and locality.—Lincolnshire formation (Hogskin member-*Oligorhynchia* bed) in Tennessee: 0.4 mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Discussion.—This species is characterized by its small size, wrinkled visceral region, and long, abruptly geniculated trail. Part of this characterization immediately suggests *D. palustris*, but that species is a larger one, with a shorter and less strongly geniculated trail.

DACTYLOGONIA PRONA (Willard)

Leptaena prona WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 279, pl. 3, figs. 15, 16, 1928.

Type.—Holotype: M.C.Z. 8620.

Horizon and locality.—Lincolnshire formation (*Dinorthis atavoides* zone) in Virginia: Near Goodwins Ferry on New River, Giles County.

Discussion.—The specimen on which this species is based is a very imperfect one with one side missing. Dimensions in millimeters based on the half dimension are; length 14.3, midwidth 18.2, hinge width 25.8, surface length about 20, length of trail about 7.0. The angle of geniculation is about 95° . The species is thus a fairly large one having a moderately but sharply bent trail. The antero-median region of the trail is somewhat concave, in this respect resembling *D. transversa*. It differs, however, in much larger size and more sharply geniculated trail. Its very sharply geniculated anterior also distinguishes it from *D. obsoleta*, another Lincolnshire species.

DACTYLOGONIA SCULPTURATA Cooper, new species

Plate 218, F, figures 17-21; plate 219, D, figure 10

Shell large for the genus, wider than long and with the hinge forming the widest part; sides slightly rounded and slightly oblique; anterior margin broadly rounded. Surface marked by strong and fine costellae, the latter exquisitely cancellated by fine concentric lines; 5 or 6 of the stronger costellae occupy 5 mm. at the front margin; 5 or 6 of the fine costellae fill the spaces between the strong costellae.

Pedicle valve fairly evenly and moderately convex in lateral profile and with no pronounced place of geniculation; anterior profile broadly and moderately convex. Umbonal and median regions somewhat swollen; lateral slopes long and moderately steep. Interarea long.

Brachial valve moderately and broadly concave with the maximum concavity in the median region; umbo sulcate; lateral areas somewhat flattened.

Measurements in mm.—Holotype, length 16.2, brachial length 14.1, midwidth 21.8, hinge width 22.5, thickness 3.8, surface length 18.0.

Types.—Holotype: 117598a; figured paratype: 117598b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: On the McLish Ranch, sec. 24, T. 1 S., R. 7 E., Johnston County; 2,300 feet south and 2,000 feet west of the northeast corner sec. 36, T. 1 S., R. 7 E., Johnston County; Baptist grounds along Falls Creek, SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 1 S., R. 2 E., Murray County.

Discussion.—This species is characterized by large size and the regularity and beauty of its sculpture. Its larger size suggests comparison with *D. obsoleta* (Butts), but that species is more strongly convex and more strongly geniculated.

DACTYLOGONIA STRASBURGENSIS, Cooper, new species

Plate 186, E, figures 15-19

Shell large for the genus, length and width nearly equal; sides rounded; anterior margin strongly rounded; surface marked by fine, distant strong radii numbering about 4 in 5 mm. at the front margin. Spaces between strong costellae marked by 4 or 5 fine costellae which are cancellated by fine concentric lines.

Pedicle valve with unevenly convex lateral profile, the posterior half somewhat flattened but the anterior half moderately convex. Anterior profile moderately domed; umbo narrowly convex, the convexity forming a low and short fold that disappears posterior to the middle; flanks bounding fold flattened to gently concave.

Brachial valve having a shallow concavity with the maximum depth just anterior to the middle; visceral region gently concave to nearly flat. Interior with short and delicate cardinalia.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length |
|---------------------|--------|-----------------|----------|-------------|-----------|----------------|
| Holotype | 19.1 | ? | 21.2 | 21.2 | ? | 23.0 |
| Paratype (117600a). | 24.7 | ? | 23.5 | 22.8 | ? | 30.5 |
| " (117600b). | ? | 17.1 | 24.0 ? | 28.4 | ? | 19.5 |

Types.—Holotype: 117600c; figured paratypes: 117599a, 117600a; unfigured paratypes: 117599b, 117600b,d.

Horizon and locality.—Edinburg formation (*Cyrtototella* zone) in Virginia: In ravine opposite switch, $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Discussion.—This is a large species characterized by considerable depth by virtue of a long trail. The visceral area is short, but the trail is exceptionally long and the sculpturing prominent. The species approaches *D. magna* in size and depth but differs in sculpture.

DACTYLOGONIA SUBAEQUICOSTELLATA Cooper, new species

Plate 217, J, figures 27-31; plate 219, A, figure 1; plate 219, C, figures 6-9

Shell about medium size to small for the genus, with the hinge narrower than the greatest shell width which is just anterior to the hinge. Lateral margins sloping gently toward the middle; anterior margin broadly rounded. Surface marked by narrow, elevated, rounded costellae of nearly equal size, spaced about 17 in 5 mm. at the front.

Pedicle valve gently convex, with the greatest convexity in the anterior half; flexed portion not prominent, point of flexure about 7 mm. anterior to the beak; umbonal region slightly swollen, the fullness continued anteriorly to the middle; on each side of this median elevation the valve is slightly flattened or sunken to the margins. Palintrope long, interarea flat, apsacline.

Brachial valve with point of flexure 6 mm. anterior to the beak and at this point having its greatest concavity. The point of flexure on this valve is stronger than that on the pedicle valve; median region somewhat more concave than the surrounding areas and the region about the cardinal extremities flattened. Palintrope unusually long and flat. Brachial interior with prominent adductor plates and small cardinal process.

Measurements in mm.—Holotype, length 10, midwidth 12.9, hinge width 11.4, surface length 11, brachial valve length 8, thickness 2.2.

Types.—Holotype: 117602; figured paratypes: 117601b,c, 117603; unfigured paratype: 117601a.

Horizon and locality.—Lower Bromide (Mountain Lake member) in Oklahoma: McLish Ranch, sec. 24, T. 1 S., R. 7 E.; 2 miles southeast of McLish Ranch, 3 miles northwest of Bromide, Johnston County; between Sylvan and Mill Creeks on west branch of Sycamore Creek, sec. 27, T. 3 S., R. 4 E., Carter County.

Discussion.—This is a small and moderately concave species with fairly strong and crowded costellae. Its general form is like that of *D. sculpturata* but the size and general appearance suggest *D. concentrica*, which species, however, is flatter, somewhat smaller, and less strongly ornamentated.

DACTYLOGONIA TRANSVERSA Cooper, new species

Plate 217, C, figures 4, 5

Shell considerably wider than long, with the hinge forming the widest part; sides short and slightly oblique; anterior margin somewhat truncated to emargi-

nate; ornamentation obscure because of poor preservation but of the usual type in the genus, consisting of a mat of fine costellae separated into groups by stronger ones.

Pedicle valve unevenly convex in lateral profile; the visceral or posterior part very slightly convex; trail moderately long; angle of geniculation about 100° . Geniculation occurring about 9 mm. anterior to the beak. Umbonal region slightly convex but most of visceral area flattened; trail slopes steep. Muscles deeply inserted.

Brachial valve with visceral region nearly flat, umbo concave, and anterior sharply geniculated toward the brachial valve; deepest part at place of geniculation. Interior with strongly developed ridge at the place of geniculation; adductor blades well developed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thick-ness | Surface length | Trail length |
|----------------|--------|-----------------|----------|-------------|------------|----------------|--------------|
| Holotype | 12.6 | 11.3 | 22.9 | 23.0+ | ? | ? | 7.0+ |
| Paratype | 14.7 | ? | 21.0 | 23.6 | ? | 20.0 | 10.0 |

Types.—Holotype: 117604b; unfigured paratype: 117604a.

Horizon and locality.—Botetourt formation in Virginia: Between U. S. Highway 60 and Whistle Creek from 1 to $2\frac{1}{2}$ miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species is characterized by its steep trail and transversely rectangular outline. Its form is like *D. geniculata*, but it is larger and more transverse. Its resemblance to *D. prona* is strong, but comparison with that species is difficult because details of the brachial valve are unknown. Nevertheless, *D. prona* appears to be a much less transverse species than the Botetourt form.

DACTYLOGONIA sp. 1

Plate 228, C, figure 19

The material of this species consists of a poorly preserved and incomplete adult and an interior of the pedicle valve. The species was large, having a visceral area extending 13 mm. anterior to the beak. The trail is mostly missing. The interarea is short, and the specimen is quite thin. Thus the species was large and thin bodied.

The pedicle interior indicates short but flaring dental plates with short and narrow umbonal cavities. The muscle field is moderately large and subcircular in outline; the diductors are flabellate; the adductor scars are somewhat elongate and separated anteriorly by a low ridge. The remainder of the interior is sparsely papillose.

Figured specimen.—117605.

Horizon and locality.—Benbolt formation in Virginia: $\frac{1}{4}$ mile north of the school at Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Same formation in Tennessee: About 0.1 to 0.2 mile north of the road, 1.4 miles northeast of Lee Valley, Pressmens Home (T.V.A. 171-NE) Quadrangle.

DACTYLOGONIA sp. 2

Plate 219, H, figure 15

Two specimens were taken from the rotted Botetourt material at the junction of Virginia Highways 731 and 724 about 2 miles northwest of Brownsburg, Lexington (15') Quadrangle. These specimens show the muscle field to perfection. No dental plates are preserved in either specimen. The diductor scars are elongate and somewhat tear shaped. The adjustor scars appear outside the diductors. They are shorter than the diductors and are also tear shaped. The diductor scars extended directly anteriorly. The adductor scars are small and narrowly elongate and separated by a slight median ridge.

Figured specimen.—117607a.

DACTYLOGONIA sp. 3

Plate 217, E, figures 8-10

This small *Dactylogonia* is most suggestive of *D. parva* but differs in having a shorter trail and a somewhat less geniculated anterior and in not having the prominent ridge at the place of geniculation. This may be the young of some larger species, but the early geniculation suggests a small adult.

Figured specimen.—117608.

Horizon and locality.—Benbolt formation in Virginia: West of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

DACTYLOGONIA sp. 4

Plate 194, D, figures 23-27

Small, wider than long. Pedicle valve with visceral region gently convex in lateral profile and with an angle of geniculation of about 115° . Point of geniculation about 6 mm. anterior to the beak. Trail rounded, short. Surface marked by prominent, somewhat irregular concentric lines cancellated by fine radial lines. Larger costellae obscure. Brachial valve gently concave.

Measurements in mm.—117609, length 8.9, brachial length 7.6, midwidth 11.1+, hinge width 11.3+, thickness 1.4, surface length 10.5, trail length 3.5.

Figured specimen.—117609.

Horizon and locality.—Sevier formation in Tennessee: $\frac{1}{4}$ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—This species is suggestive of *D. concentrica* and is marked somewhat like it, but the brachial valve is more deeply concave and the trail is longer.

DACTYLOGONIA sp. 5

Plate 217, I, figures 23-26

This is an unusually well preserved specimen, but its form and lack of conspicuous geniculation suggest that it is the young of a larger species not yet known. The specimen is wider than long, with a gently convex pedicle valve and a moderately concave brachial valve. The ornamentation consists of fairly regular distant

larger costellae numbering 11 or 12 with short intercalations of large costellae at the front. These are separated from each other by 8 or possibly more fine costellae. Concentric elements are not conspicuous. The foramen is large. The brachial umbo is narrowly swollen and smooth, matching a smooth area in the vicinity of the pedicle foramen.

Measurements in mm.—117610, length 8.1, brachial length 7.6, midwidth 10.9, hinge width 11.9, thickness 1.7, surface length 9.0, height 1.9.

Figured specimen.—117610.

Horizon and locality.—Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

DACTYLOGONIA sp. 6

Plate 218, E, figures 15, 16

Shell large for the genus, wider than long, with the hinge forming the widest part. Pedicle valve gently convex in lateral profile, mostly so in the anterior quarter which forms an inconspicuous trail. Umbonal and median region somewhat narrowly swollen to form a low but inconspicuous fold on the posterior three-quarters; sides with short and steep slopes. Brachial valve concave, with the maximum concavity located just anterior to the middle; visceral region gently concave; trail moderately long.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Trail length |
|-----------------------------|--------|-----------------|----------|-------------|-----------|----------------|--------------|
| Pedicle valve (117611a)... | 12.5 | ? | 17.9 | 21.6 | ? | 14.0 | 2.0 ? |
| Brachial valve (117611d)... | ? | 14.3 | 24.6 ? | 20.3 | ? | 16.0 | 6.0 |

Figured specimen.—117611a; measured specimen: 117611d.

Horizon and locality.—Probably Benbolt formation (30 feet above the 225-foot marble) in Tennessee: At Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species is a flatly convex one, not like any of those described. Its ornamentation is suggestive of *D. alternata*, but it is not so strongly geniculated.

DACTYLOGONIA sp. 7

Plate 217, G, figures 16-19

Shell of about medium size for the genus, wider than long, transversely subrectangular. Surface marked by fine radial lines crossed by fine concentric lines. Visceral region of pedicle valve nearly flat in lateral profile, slightly convex in anterior profile. Place of geniculation about 8 mm. anterior to the beak; angle of geniculation about 115° . Trail short. Foramen large. Visceral region of brachial valve gently concave; umbo and median region of visceral area sulcate.

Measurements in mm.—117612a, length 11.6, brachial length 10.2, midwidth 17.2, hinge width ?, thickness 2.2, surface length 13.5, trail length 5.0.

Figured specimens.—117612a,b.

Horizon and locality.—Whistle Creek formation in Virginia: Foot of Brushy

Hills road to Lexington, $1\frac{1}{2}$ miles northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species suggests *D. geniculata*, but the brachial valves are more concave, the geniculation is less sharp, and the trail shorter.

DACTYLOGONIA sp. 8

Plate 216, A, figures 1-4

Shell small for the genus, wider than long; visceral region of both valves marked by more or less obscure concentric wrinkles. Visceral region of pedicle valve flat in lateral profile; point of geniculation about 6 mm. anterior to the beak; angle of geniculation about 95° ; trail moderately long, convex in profile. Place of geniculation marked by a slight rim. Brachial valve with visceral part nearly flat. Umbo and median part gently sulcate; trail narrowly and sharply deflected.

Measurements in mm.—117613a, length 7.9, brachial length 7.0, midwidth 10.9, hinge width 12.0, thickness 2.3, surface length 10.5, trail length 5.0.

Figured specimen.—117613a.

Horizon and locality.—Poteet formation (Yellow Branch member) in Virginia: Along the Yellow Branch road, 5 miles southeast of Rose Hill (T.V.A. 161-NE) Quadrangle.

Discussion.—The size and visceral region of this species suggest *D. palustris*, but geniculation is too sharp and the trail too long.

CYPHOMENA Cooper, new genus

(Greek *kyphos*, bent; *mene*, crescent)

Shell generally transversely subrectangular in outline, concavo-convex in profile; valves strongly geniculated toward the brachial valve. Surface marked by fine subequal radial costellae crossed by fine concentric lines. Costellae not grouped into zones of different sizes as in *Dactylogonia*. Pseudopunctate.

Pedicle valve with small but stout teeth; thick plates extend as a rim nearly completely around the suboval muscle field. Diductor scars subcrescentic, elongate, located on each side of a short, low median ridge which divides the muscle field but is extended anteriorly for a short distance only. Incipient vascula media extend directly anteriorly from the anterior ends of the diductors. Foramen and pseudodeltidium leptaenoid.

Brachial interior with broad, shallow sockets, the inner wall of which is formed by the outer face of a broad, flat brachiophore; notothyrial cavity filled by a thick platform which supports the cardinal process and nearly buries the brachiophore with lateral extensions. Median ridge short, extending from notothyrial platform and dividing the posterior adductors. Cardinal process formed of 2 narrow, short-shafted pieces with flat myophores. Chilidium strongly convex and covering part of the myophore surfaces. Adductor field narrowly triangular or arrow shaped in outline with the apex directed anteriorly; posterior adductors the larger, located outside the anterior pair and apparently divided into pairs

by a more or less thick oblique ridge. Anterior pair elongate and separated by a short, low median ridge.

Genotype.—*Leptaena homostriata* Butts, Virginia Geol. Surv. Bull. 52, p. 110, pl. 95, figs. 24, 25, 1942.

Discussion.—*Cyphomena* is essentially a side line of *Leptaena* which never developed the concentric wrinkling of the visceral region and which, as far as now known, was short lived. Besides the lack of wrinkling, *Cyphomena* differs from *Leptaena* in lacking the standardized and abrupt geniculation of both valves. The brachial valve is more suggestive of *Leptaena* in its geniculation because it has a raised rim on the inside and a precipitous face to the trail. This is not so of the pedicle valve, however.

Inside the brachial valve the musculature is like that of *Leptaena* including the presence of the small longitudinal ridge. The brachial valve shows the brachiophores more clearly than most specimens of *Leptaena*, in which these structures are lost or covered. Although the muscle area of the brachial valve of the two genera is similar, that of *Cyphomena* is generally somewhat elevated or marked by a thickened rim, emphasizing its arrow-shaped form.

At the present time *Cyphomena* is certainly known only from Edinburg and Oranda formations in Virginia, Maryland, and southern Pennsylvania. The faunas of these two formations are closely related. From the material studied no significant evolutionary changes were detected during this short interval. A doubtful species is known from the Chaumont near Montreal, Quebec, Canada.

CYPHOMENA ANGULATA Cooper, new species

Plate 224, A, figures 1-8; plate 224, C, figures 21, 22; plate 228, A, figures 1-7

Shells thick, wider than long and with the hinge forming the widest part; cardinal extremities alate; sides gently oblique, anterolateral extremities narrowly rounded; anterior margin gently convex to gently emarginate. Costellae numbering about 4 to the millimeter at the front margin of an adult.

Pedicle valve strongly convex in lateral profile and with the maximum convexity near the middle; anterior profile broadly and moderately convex. Umbo narrowly convex, the convexity continued anteriorly as a low fold to about the place of geniculation 4 or 5 mm. anterior to the beak. Geniculated area broadly rounded; trail moderately long and gently convex; median region of trail marked by a more or less prominent sulcus. Muscle area deeply impressed.

Brachial valve moderately concave with the most concave part just posterior to the place of geniculation. Visceral region gently concave; umbo slightly sulcate; geniculation moderate. Muscle area moderately thickened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Trail length |
|-----------------------|--------|-----------------|----------|-------------|-----------|----------------|--------------|
| Holotype | 10.3 | 9.2 | 14.1 | 15.3 | 3.9 | 15.5 | 9.0 |
| Paratype (117617a)... | 9.7 | 8.7 | 12.8 | 14.8 | 2.6+ | 13.0 ? | 6.0 ? |

Types.—Holotype: 117619a; figured paratypes: 117614a, 117616a, 117617a, 117618, 117619b; unfigured paratypes: 117614b,c, 117616b,c, 117617b.

Horizon and locality.—Edinburg formation (*Cyrtototella* zone) in Virginia: In the ravine at the switch $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Edinburg formation (*Nidulites* zone) in Virginia: Beside the road along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg; on U. S. Highway 11, at Hupp Hill, 1 mile north of Strasburg, Strasburg (15') Quadrangle.

Edinburg formation (Liberty Hall facies) in Virginia: $1\frac{1}{2}$ miles south of Wadesville, Winchester (15') Quadrangle.

Shippensburg formation (nodular shaly zone below *Nidulites*) in Pennsylvania; $1\frac{3}{4}$ miles west of Kauffman, Chambersburg (15') Quadrangle; in the railroad cut $2\frac{1}{2}$ miles southwest of Marion, Chambersburg (15') Quadrangle.

Shippensburg formation (*Nidulites* zone) in Maryland: In a cut on the west bank of Conococheague Creek on U. S. Highway 40, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—This is a rare species, and good specimens are very difficult to obtain. In size it is intermediate between *C. homostriata* and *C. grandis*, being generally larger than the first. Its sides are usually more oblique and the cardinal extremities more alate than in *C. homostriata*. *Cyphomena homostriata* is somewhat more finely costellate than the lower Edinburg species and has a flattened umbo, whereas *C. angulata* has the umbo narrowly swollen to form a short, low fold.

CYPHOMENA GRANDIS Cooper, new species

Plate 224, D, figures 23-36

Shell large for the genus, transversely subrectangular, the hinge forming the widest part; sides gently oblique; anterolateral extremities moderately rounded; anterior margin indented; surface marked by 3 to 4 costellae in 1 mm. at the front margin.

Pedicle valve with lateral profile strongly convex and with the greatest convexity located anterior to the middle; visceral region convex in lateral profile. Anterior convex, strongly domed and with steep sides. Visceral region moderately convex; umbo gently convex; geniculated region narrowly convex; trail long, gently convex in lateral profile. Median area of trail occupied by a broad and shallow sulcus. Interareas subequal. Muscle area small, subcircular.

Brachial valve concave, the most concave part located just posterior to the place of geniculation. Visceral region nearly flat; umbo nearly flat.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Trail length |
|-----------------------|--------|-----------------|----------|-------------|-----------|----------------|--------------|
| Holotype | 11.7 | 10.5 | 18.6 | ? | 4.3 | 19.0 | 11.0 |
| Paratype (117621b)... | 13.9 | ? | 20.0 | ? | ? | 22.5 | 12.0 |
| " (117620) | 11.6 | 10.0 | 17.3 | ? | 4.4 | 16.5 | 7.0 |

Types.—Holotype: 117621a; figured paratypes: 117620, 117621b; unfigured paratype: 117621c.

Horizon and locality.—Martinsburg formation (part with *Brongniartella* =

Salona) in Virginia: On County Highway 617=910, 0.15 miles north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This is the largest known species of the genus and in its adult form is thus readily distinguished from the other two known species. It is proportionately wider than the other two and is somewhat more strongly costellate.

CYPHOMENA HOMOSTRIATA (Butts)

Plate 223, D, figure 7; plate 224, B, figures 9-20

Leptaena homostriata BUTTS, Virginia Geol. Surv. Bull. 52, p. 110, pl. 95, figs. 24, 25, 1942.

Small, subrectangular in outline and with the hinge forming the widest part; sides gently oblique; anterolateral extremities narrowly rounded; anterior margin gently convex to truncated. Surface finely costellate, 4 to 6 costellae in a millimeter at the front margin of an adult.

Pedicle valve strongly convex in lateral profile, the greatest convexity located at about the middle; anterior profile domed and with steep sides but the median part depressed by a sulcus. Visceral region nearly flat in profile; geniculated part narrowly rounded; trail gently convex in lateral profile. Visceral region gently convex; trail moderately long and marked by a prominent sulcus. Flanks of trail bounding sulcus rounded and somewhat swollen.

Brachial valve gently concave, the deepest part located near the place of geniculation. Visceral region gently concave. Trail short, marked medianly by a low and inconspicuous fold. Muscle area narrowly arrow shaped, moderately thickened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Surface length | Trail length |
|-----------------------|--------|-----------------|----------|-------------|-----------|----------------|--------------|
| Holotype | 8.1 | 7.4 | 10.4 | 11.3 | 3.2 | 13.5 | 6.0 |
| Paratype (117622).... | 7.7 | 6.6 | 10.3 | ? | 3.0 | 11.5 | 6.0 |
| " (117623a)... | 8.2 | 7.4 | 11.7 | 11.7 | 2.7 | 11.5 | 6.0 |

Types.—Holotypes: 97545, figured hypotypes: 117615, 117622, 117623a, 117624.

Horizon and locality.—Oranda formation in Virginia: Along the railroad $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle; on the Shenandoah River, $1\frac{1}{2}$ miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle; Bowman Farm, 0.3 mile east of U. S. Highway 11, on the south edge of Woodstock, Edinburg (15') Quadrangle; just west of the junction of Virginia County Highways 617=910, and 777, about $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle.

Oranda formation in Pennsylvania: $1\frac{3}{4}$ miles west of Kauffman, $\frac{1}{2}$ mile north of Greencastle, Chambersburg (15') Quadrangle.

Discussion.—This species is the smallest of the three known species and is generally somewhat squarer than the other two in outline. It is also somewhat more finely costellated and has a somewhat flattened umbonal region. It is usually not so alate as *C. angulata*.

CYPHOMENA ? RADIALIS (Okulitch)

Plate 223, G, figure 18

Leptaena radialis OKULITCH, Canadian Field-Nat., vol. 49, No. 6, p. 99, pl. 1, fig. 9, 1935.

The outline, profile and ornamentation suggest affiliation with *Cyphomena*.

Type.—Holotype: McGill Univ. (no number).

Horizon and locality.—Lower Leray formation (=Chaumont) in Quebec, Canada: At St. Vincent de Paul.

MURINELLA Cooper, new genus

(Latin *murus*, wall)

Generally large and thick shells, semielliptical to subquadrate in outline; generally biconvex or planoconvex to rarely concavo-convex; pedicle valve generally strongly convex; costellate, the costellae of two sizes, the stronger ones standing out in a mat of finer ones and dividing the finer ones into groups. Fine costellae may or may not be cancellated by fine concentric threads. Pseudopunctate.

Pedicle valve with large, wide, strongly convex pseudodeltidium; pedicle foramen moderately large, leptaenoid in character. Teeth wide, small; dental plates short, flaring, separated from shell wall by small and narrow umbonal chambers; muscle area large and subcircular; diductor-adductor scars flabellate; adductor scars long and slender, separated by a low ridge that is continued anterior to the anterior ends of the muscles for a considerable distance; margin usually somewhat thickened.

Brachial interior with an obscure, thin and flat-bladed brachiophore supported by lateral swellings on each side of the cardinal process; sockets deep and wide; cardinal process consisting of 2 short-shafted processes located on a more or less thickened notothyrial platform; myophore surfaces tear shaped, concave; median ridge extending anterior to the cardinal process short, low, obscure and not extending anterior to the posterior adductors. Adductor field large, posterior adductors 4 in number, the outer 2 larger than the inner 2; inner and other scars often separated by low, oblique ridges; anterior pair small; 2 vascula media extending directly anterior to the anterior adductor pair and extending anteriorly nearly to the flange; marginal area marked by a more or less strongly elevated peripheral band or flange.

Genotype.—*Murinella partita* Cooper, new species.

Discussion.—Leptaenoid characters of this genus are: The fairly large apical foramen; the large and swollen pseudodeltidium, the subcircular muscle field of the pedicle valve; the short-shafted, bilobed cardinal process; and the arrangement of the adductor scars. This genus differs from most other leptaenoids in having planoconvex to biconvex valves. One or two species have concave brachial valves, but even these species have the younger stages characterized by both valves being more or less strongly convex.

Murinella is ornamented like *Dactylogonia* but is not strongly geniculated like it and the brachial interiors are quite unlike. Although *Murinella* often has

ridges dividing parts of the adductor field these do not take the form of the blades so characteristic of *Dactylogonia*. The shape and ornamentation serve to distinguish *Leptaena*, *Cyphomena*, and *Bellimurina* from *Murinella*. The inner flange just inside the anterior margin of the brachial valve is a character distinguishing this genus from all other known leptaenoids.

Although *Murinella* is a distinctive and fairly widely distributed genus both stratigraphically and geographically, the known specimens are not many. The genus seems to be quite rare except in a few places.

MURINELLA BICONVEXA Cooper, new species

Plate 227, C, figures 8-16

Shell of about medium size for the genus, subequally biconvex; greatest width at about middle; hinge width less than greatest width; anterior commissure rectimarginate; sides somewhat narrowly rounded; anterior margin broadly rounded. Cardinal extremities obtuse. Surface marked by costellae of unequal size, 1 to 3 of the smaller kind separated by larger ones. Strong, elevated concentric lines cancellate the costellae.

Pedicle valve moderately and unequally convex in lateral profile with the greatest convexity located in the posterior half; anterior half somewhat flattened. Median region slightly swollen with gentle slopes to the anterior and anterolateral margins but somewhat steeper slopes to the cardinal extremities.

Brachial valve with concave umbo; profile unequally convex with the greatest convexity located at about the middle; anterior profile broadly convex; median region swollen but with gentle slopes in all directions.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.2 | 10.6 | 15.6 | 12.0 | 4.6 |
| Paratype (117629b) | 11.3 | 11.0 | 15.4 | 12.1 | 4.6 |
| “ (117630) | 10.5 | 9.8 | 14.4 | ? | 3.0 |

Types.—Holotype: 117629a; figured paratypes: 117629b, 117630.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; $\frac{3}{4}$ mile southwest of Mount Eager Church, Powder Springs (T.V.A. 154-SW) Quadrangle.

Discussion.—This species is characterized by its small size and fairly strongly convex valves. It differs from the only two other species like it in the uniformity of the convexity of the valves. *Murinella plana* is a small species nearly of the same size as *M. biconvexa*, but its brachial valve is nearly flat and the ornamentation is stronger and not so beautifully cancellated. *Murinella speciosa* is somewhat larger than *M. biconvexa*, but its pedicle valve is convex in the posterior part, becoming concave anteriorly. Its ornamentation is also somewhat stronger than that of *M. biconvexa*.

MURINELLA CANCELLATA Cooper, new species

Plate 217, H, figures 20-22

Shell large, with the widest part just anterior to the hinge, cardinal extremities rounded, obtuse; lateral margins gently rounded, sloping to the middle; anterior margin broadly rounded. Surface marked by costellae of unequal size, separating areas of fine costellae; 3 or 4 of the larger costellae occupy a space of 5 mm. at the front and as many as 10 of the finer costellae may occupy the spaces between the larger ones; all costellae are crossed by fine elevated lines, about 5 to a millimeter near the middle, which produce a cancellated effect.

Pedicle valve fairly strongly convex, with the greatest curvature anterior to the middle; umbonal region convex and area anterior to umbo somewhat swollen; lateral and anterior slopes moderately steep; valve not markedly geniculated but surface is bent toward the brachial valve about 13 mm. anterior to the beak. Palintrope short for such a large shell; interarea flat, approximately orthocline. Foramen small.

Brachial valve with visceral area slightly convex for 10 mm. anterior to the beak where the valve is bent at an obtuse angle toward the brachial valve. Geniculated rim about 6 mm. long. Chilidium short, cardinal process large.

Measurements in mm.—Holotype, length 18.8, brachial length 16.4, midwidth 23.4, hinge width 22.6, thickness 5.4.

Type.—Holotype: 117631.

Horizon and locality.—Benbolt formation in Virginia: West of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This is a large species characterized by a fairly deeply concave brachial valve and beautifully cancellated shells. It is much larger than *M. speciosa* and differently ornamented. It is very suggestive of *M. semireducta*, but that species has a less deeply concave brachial valve and is proportionately a much wider species. This species differs from *M. muralis* and *M. partita* in the strongly concave brachial valve.

MURINELLA MURALIS Cooper, new species

Plate 226, D, figures 10-28

Shell large, planoconvex in profile, semielliptical in outline; anterior commissure rectimarginate; lateral margins gently rounded; widest part of shell just anterior to hinge; anterior margin broadly rounded. Surface marked by costellae of unequal size, 4 or 5 smaller costellae between the larger ones and all crossed by strong concentric lines.

Pedicle valve strongly convex in lateral profile, with greatest convexity near the middle. Median region swollen and with moderately steep slopes to the anterior and lateral margins. Teeth moderately large with sockets parallel to the hinge; dental plates short and flaring, with small umbonal cavities separating them from the inner side of the valve. Muscle area deeply impressed, transversely elliptical to subcircular in outline.

Brachial valve nearly flat in lateral profile, interior with bilobed, cardinal process, 4 adductor septa and a thickened inner rim.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve)..... | 14+ | ? | 15.4+ | 14.8 | 4.6 |
| Paratype (pedicle valve 117636b) .. | 19.3 | ? | 22.4 | 20.0 | 5.4 |
| “ (brachial valve 117637a) .. | ? | 12.3 | 17.0 | 15.5 | 1.5 |
| “ (“ “ 117636c) .. | ? | 18.5 | 25.7 | 21.5 | 2.0 |

Types.—Holotype: 117636a; figured paratypes: 117632a, 117633, 117635c, 117636b-f, 117637a,b; unfigured paratypes: 117632b,c, 117635a,b, 117636g,h, 117637c,d.

Horizon and locality.—Wardell formation in Tennessee: In Raccoon Valley, $\frac{3}{4}$ mile northeast of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle.

Dryden formation (and Wardell part) in Tennessee: Along the road to Tazewell $1\frac{1}{2}$ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle.

Poteet formation (Yellow Branch member) in Virginia: Along the road beside Yellow Branch, 5 miles southeast of Rose Hill, Rose Hill (T.V.A. 161-NE) Quadrangle.

Discussion.—This species is characterized by its large size and generally plano-convex profile. It is most like *M. partita* from the Bromide formation of Oklahoma but differs in being less convex and in having a more extravagant development of the median ridge inside the brachial valve. The septa associated with the adductor scars in *M. muralis* are more prominently developed than they are in *M. partita*. Inside the pedicle valve of *M. muralis* the dental plates are somewhat more fully developed. The greatest width of *M. muralis* is nearer the hinge whereas in *M. partita* it is nearer the middle.

MURINELLA PARTITA Cooper, new species

Plate 223, F, figures 11-17; plate 227, D, figures 17-25

Shell large, variable, wider than long; planoconvex to biconvex, the pedicle valve being the deeper; greatest width at or near the middle; sides gently rounded; anterior margin broadly rounded; surface marked by costellae of unequal size, the larger ones separated by 2 to 4 of the finer ones.

Pedicle valve moderately convex in lateral profile and with the maximum convexity at about the middle; anterior profile moderately domed in the median region and with long, moderately steep lateral slopes; umbonal region swollen; median region swollen; anterior and lateral slopes subequal, moderately steep. Interior with subcircular muscle field confined to the posterior third; diductor scars somewhat elongated anteriorly; median ridge long and slender.

Brachial valve varying from gently convex to nearly flat in lateral profile; umbo concave, the concavity continued anteriorly at least to the middle as a shallow sulcus; flanks flat or gently convex; Interior with stout cardinal process;

adductor field moderately large; adductor processes moderately developed. Four parallel pallial trunks extend anteriorly from the adductor field.

Measurements in mm.—Holotype, length 18.2, brachial length 16.2, midwidth 23.7, hinge width 20.0 ?, thickness 6.6.

Types.—Holotype: 117639; figured paratypes: 117638, 117640.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: In the road cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; along the creek on the Fitz place, SE $\frac{1}{4}$ sec. 27, T. 2 S., R. 3 E., 1 $\frac{1}{4}$ miles west and $\frac{3}{4}$ mile south of Nebo, Murray County; in the *Sowerbyites* bed; 150 feet below the top of the Bromide 0.1 mile down the hill from the Observation Point on the Scenic Drive, 1 mile east of U. S. Highway 77, in the center NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 29, T. 1 S., R. 2 E., Murray County.

Discussion.—This species is a large one having a strong superficial resemblance to *M. muralis*. The chief differences are in the location of the greatest width of *M. partita* at or near the middle instead of near the hinge as in the Appalachian species. Differences appear in the interior also. The dental plates of *M. muralis* are the better and more fully developed, and the subperipheral rim of *M. muralis* is much more extravagantly developed than in the Oklahoma species. The latter also differs in the arrangement of the pallial trunks in the brachial valve, there being 4 in *M. partita* but only 2 in the other species.

It is interesting to note that *M. partita* was found in the reefy limestones south of Sulphur where it occurs with *Sowerbyites*.

MURINELLA PARVA Cooper, new species

Plate 217, B, figures 2, 3

Shell small for the genus, wider than long and with the greatest width at about the middle; sides gently rounded; anterior margin broadly rounded; surface marked by alternating strong and fine costellae, about 3 or 4 to the millimeter at the front margin and the stronger costellae separated by 2 to 4 costellae; entire surface covered by strong concentric, elevated lines.

Pedicle valve gently convex in lateral profile, broadly and moderately convex in anterior profile; umbonal and median regions swollen; anterior slope long and gentle; lateral slopes moderately long and moderately steep. Interarea moderately long; pseudodeltidium large and strongly convex.

Pedicle valve perceptibly concave in lateral profile; broadly concave in anterior profile; umbo concave.

Measurements in mm.—Holotype, length 9.2, brachial length 8.3, midwidth 11.4, hinge width 11.0, thickness 2.3.

Type.—Holotype: 117643.

Horizon and locality.—Whistle Creek formation, in Lexington (15') Quadrangle, Virginia: On U. S. Highway 60, 100 yards southeast of Whistle Creek, 2 miles northeast of Lexington; 1 $\frac{1}{2}$ miles northwest of Lexington.

Discussion.—This is a small species of about the same size as *M. plana*. It differs from that species, however, in having a moderately concave brachial valve and finely cancellated ornamentation.

MURINELLA PLANA Cooper, new species

Plate 227, B, figures 6, 7

Small, wider than long and with the widest part at about the middle; sides and anterior margin rounded; surface marked by fairly strong costellae with finer ones intercalated between the stronger ones in several generations; 2 of the stronger costellae in 1 mm. at the front margin.

Pedicle valve moderately convex and with the greatest depth at the middle; anterior profile broadly domed, rounded in the middle with moderately long and moderately steep lateral slopes. Umbonal and median regions swollen. Anterior slope short, gentle.

Brachial valve nearly flat to slightly convex in lateral profile; anterior profile gently convex. Umbo gently concave.

Measurements in mm.—Holotype, length 9.6, brachial length 8.5, midwidth 11.5, hinge width 9.6, thickness 3.7.

Types.—Holotype: 117644a; unfigured paratype: 117644b.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: Evans Ferry about 1 mile north of Indian Creek on U. S. Highway 25E, Howard Quarter (T.V.A. 162-NE) Quadrangle.

Discussion.—This species is characterized by a flat brachial valve, strong costellae, and small size. It differs from *M. parva* which has a concave pedicle valve and from *M. speciosa* in which the brachial valve is convex in the posterior half but is concave in the anterior half.

MURINELLA SEMIREDUCTA Cooper, new species

Plate 227, A, figures 1-5

This is a large species having a transversely semielliptical outline and with the maximum width at about the middle. Pedicle valve not preserved except for the posterior, probably moderately to strongly convex. Brachial valve with concave umbo. Region surrounding umbo for about half the valve length nearly flat; area surrounding flattened part gently concave and with the margins deflected moderately toward the brachial valve. Pedicle interior with fairly large muscle field, subcircular in outline; dental plates strong, moderately divergent, and with fairly large and deep umbonal cavities.

Brachial interior with broad notothyrial platform, small cardinal process, and low adductor ridges. Ornamentation like that of *M. cancellata* with strong costellae separated by groups of finer ones, all cancellated by concentric costellae. Submarginal rim long and almost reaching margin.

Measurements in mm.—Holotype, length 15.8, brachial length 14.7, midwidth 26.0, hinge width 22.4, thickness ?.

Type.—Holotype: 117645.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: On the Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle.

Discussion.—This species is characterized by its large size, transversely semi-

elliptical outline, and the flattened posterior half of the brachial valve. It is most like *M. cancellata* in general proportions and ornamentation but differs in having its greatest width nearer the middle, in being less concave anteriorly and in a generally flatter brachial valve.

MURINELLA SPECIOSA Cooper, new species

Plate 228, D, figures 20-26

Shell large, transversely semielliptical; widest part at about the middle; sides rounded; anterior margin broadly rounded; surface marked by fairly strong alternating costellae, the larger ones separated by 1 to 3 finer ones.

Pedicle valve moderately convex in lateral profile and with the maximum convexity near the middle; anterior profile broadly and moderately convex; umbonal region gently convex; median region moderately swollen; anterior slopes shorter and steeper than the lateral ones; interarea moderately long; pseudodeltidium somewhat narrow, convex.

Brachial valve unevenly convex in lateral profile, the posterior half moderately convex but the anterior half moderately concave; umbo gently concave; region immediately anterior to the umbo moderately swollen to about the middle of the valve; around the swollen area the valve is moderately concave but the marginal region is turned back toward the brachial valve.

Measurements in mm.—Holotype, length 14.0, brachial length 12.5, midwidth 18.0, hinge width 13.7, thickness 5.2.

Type.—Holotype: 117646.

Horizon and locality.—Lincolnshire formation (Hogskin member—*Oligorhynchia* zone) in Tennessee: 0.4 mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Discussion.—This species is suggestive of *Murinella cancellata*, but it is much smaller and the posterior half of the brachial valve is much more convex. *Murinella biconvexa* is similar in size but has a brachial valve of almost the same convexity as that of the pedicle valve.

MURINELLA sp. 1

Plate 226, B, figures 3, 4

Species represented by a single impression of the interior showing the muscle field to perfection. The scars of the diductors are subflabellate; the small tear-shaped adjustor scars appear outside the diductors. The adductor scars are small and located on the sides of the narrow median ridge. The posterior ends of the *vascula media*, parallel and separated only by a thin ridge, appear at the anterior ends of the diductors.

Figured specimen.—117647.

Horizon and locality.—Murfreesboro formation in Tennessee: On the east edge of Murfreesboro, Murfreesboro (15') Quadrangle.

MURINELLA sp. 2

Plate 217, A, figure 1

Large, transversely semielliptical in outline, with the hinge equal to or slightly less than the greatest shell width; sides rounded, slightly oblique. Anterior margin broadly rounded; surface marked by alternating strong and fine costellae.

Pedicle valve unevenly convex in lateral profile, the most convex part being the middle; anterior profile broadly domed. Posterior half or more gently convex to nearly flat; anterior half somewhat abruptly bent toward the brachial valve to form a long trail which is gently convex in lateral profile. Muscle area small, subcircular. Brachial valve nearly flat.

Figured specimen.—117648a.

Horizon and locality.—Tulip Creek formation in Oklahoma: On west branch of Sycamore Creek, sec. 27, T. 3 S., R. 4 E., Johnston County.

MURINELLA sp. 3

Plate 226, A, figures 1, 2

A single brachial valve is nearly flat in lateral and anterior profile and is marked by distant, strong costellae separated by numerous (as many as 11) fine costellae all cancellated by fine concentric lines. The interior is distinctly leptaenoid with a broad notothyrial platform surmounted by a small, delicate leptaenoid cardinal process. The muscle area is indistinct and a double subperipheral rim suggests the type of structure in the brachial valve of *Murinella*.

Figured specimen.—117649.

Horizon and locality.—Little Oak formation (top third) in Alabama: 1 mile north of Pelham, Bessemer Iron District (15') Quadrangle.

LIMBIMURINA Cooper, new genus(Latin *limbus*, border; *murus*, wall)

Shell attaining a length and width of about 1 inch; subrectangular to semielliptical in outline; compressed biconvex in profile; anterior and sides marked by an elaborate frill geniculated toward the pedicle valve. Visceral region marked by irregular wrinkles; entire surface marked by fine costellae and concentric lines of growth.

Pedicle valve with small foramen, strong divergent dental plates, a moderately large, subcircular muscle area surrounded by elevated ridges extending from the dental plates and a short low, median ridge dividing the muscle field and extended some distance anterior to it.

Brachial interior with thin, bladelike brachiophores, wide sockets, moderately thick notothyrial platform bearing a cardinal process consisting of 2 short shafted prongs with concave myophores. Adductor field with prominent oblique ridges.

Genotype.—*Limbimurina insueta* Cooper, new species.

Discussion.—The distinctive feature of this genus is the elaborate frill which

surrounds the visceral region, and which probably served as a sort of anchoring device. The visceral part of the shell is usually small and is separated from the frill by a deep and prominent groove. The posterior side of the frill is a steep wall extending in the direction of the pedicle valve and ending in a narrow ridge. The main part of the frill in the pedicle valve extends from this ridge.

The visceral area of the brachial valve is surrounded by a sharp and narrow ridge which is elevated more or less strongly above the visceral region. The anterior slope of this ridge is steep and long and ends in a narrow groove. At the anterior end or bottom of this slope the main part of the frill extends forward and laterally.

The interior details of this genus are not easily discerned from the material available. Each of the features recorded has been gleaned from study of many specimens. To date no good interiors have been found. The information on the cardinalia were derived from 2 fragments dissolved out of Lower Edinburg limestone. In spite of these difficulties most of the details have been learned.

The interior of this genus is most like that of *Murinella* and shares with it the prominent dental plates and the more or less strong adductor ridges. The interior of the pedicle valve of *Murinella* is not provided with the prominent, elevated ridge around the visceral area seen in *Limbimurina*, but that is a deviation brought about by the elaborate frill.

Limbimurina is not rare in parts of the Rodman formation in central Pennsylvania but is a rare shell in the lower part of the Edinburg formation. The occurrence of this bizarre form in the Lower Edinburg and the high Chambersburg and Salona emphasizes again the continuity of these two faunas. In the Rodman of central Pennsylvania *Limbimurina* is most often found in coarse calcarenites. It is not possible to be sure if this was the actual environment of this peculiar brachiopod or if the shells only represent debris washed into a sand bank. The shells in the calcarenite are usually single valves only and thus may have been banked up with the lime sand and broken bryozoans as a part of the bottom debris.

The occurrence of *Limbimurina* shells in the Edinburg formation is not unlike that in the Rodman formation. Here, too, the lithology is either calcarenite or shell breccia, and most of the specimens are taken as single valves. The environment is one of agitated water and if it was the locale for these shells, the expanded frills would have been of advantage in keeping the shells from being tipped over, particularly if steadied by a pedicle.

LIMBIMURINA BREVILIMBATA Cooper, new species

Plate 173, G, figures 32-34; plate 222, E, figures 6-9; plate 223, B, figure 4

Shell large, attaining a width of 0.6 inch; transversely subrectangular in outline; hinge forming widest part; sides oblique; anterior margin broadly rounded; surface marked by strong costellae separating groups of fine costellae beautifully cancellated by concentric lines; as many as 6 fine costellae constituting a group. Wrinkles irregular and variable but those along the posterior margin strong and fairly regular.

Pedicle valve gently convex in lateral profile; anterior profile gently convex but with the median region narrowly and sharply pinched in the middle; umbo and median region somewhat narrowly swollen to form an indistinct fold that disappears at the place of geniculation. Visceral region 8 to 9 mm. long; posterior slope of trail short; trail short, moderately steep.

Brachial valve fairly evenly and gently convex in anterior and lateral profiles; median region marked by an indistinct sulcus; flanks gently convex; trail short.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Length of visceral region | Trail length |
|------------------------|--------|-----------------|----------|-------------|-----------|---------------------------|--------------|
| Holotype | 11.4 | ? | 16.4 | 18.0 | 1.5 | 9.0 | 2.0 |
| Paratype (117661a).... | 13.0 | ? | 16.8 | 20.5 | 2.5 | 8.5 | 5.0 |
| " (117662b).... | ? | 8.3 | 10.8 | 11.6 | 1.4 | 8.3 | ? |
| " (117662c).... | ? | 10.7 | 13.6 | 18.0 | ? | 8.3 | 2.5 ? |

Types.—Holotype: 117662a; figured paratypes: 117661a,b, 117662b-d; unfigured paratypes: 117662e-i.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Strasburg (15') Quadrangle, Virginia: On the railroad at the switch and in the ravine about $\frac{1}{8}$ mile east of Strasburg Junction; on the south side of the road 0.2 mile east of Strasburg Junction.

Botetourt formation: Same as above.

Discussion.—This species is represented by about 25 specimens, but not one of them is a complete valve except the holotype. Several of the specimens evidently represent immature forms that have not yet developed the trail. One very poorly preserved specimen from the ravine east of Strasburg Junction shows this species to have been nearly as large and extravagantly developed as *L. insueta* from the Rodman formation of Pennsylvania. The specimen referred to preserves part of the trail which is 8 mm. long.

This species differs from *L. insueta* in having stronger and more regular wrinkles along the posterior margin and in having a shorter trail.

LIMBIMURINA INSUETA Cooper, new species

Plate 220, D, figures 18-23; plate 221, F, figures 37-42

Shell variable, attaining an inch in length and width; subquadrate to subrectangular in outline; sides nearly straight; anterior margin broadly rounded; surface finely costellate; visceral region marked by fine irregular wrinkles.

Visceral region of pedicle valve gently convex in both profiles; umbo narrowly swollen; median region gently swollen to form an indistinct fold; flanks flattened. Place of geniculation about 9 mm. anterior to the beak. Posterior slope of trail long and steep; trail variable, usually fairly long.

Brachial valve gently convex in lateral and anterior profile; visceral region bounded anteriorly by a sharp rim; umbo sulcate; sulcus somewhat obscure anterior to the umbo; flanks gently convex; posterior of trail marked by a deep trough peripheral to the visceral area; trail long.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Height | Visceral disk length | Trail length |
|-----------------------|--------|-----------------|----------|-------------|--------|----------------------|--------------|
| Holotype | 15.3 | ? | 15.4 | 15.0 | 3.1 | 8.5 | 7.0 |
| Paratype (117660a)... | 23.9 | ? | 30.4 | 26.2 | 3.0 | 9.5 | 15.0 |
| " (117660b)... | ? | 16.8 | 20.0 ? | 26.0 | 2.2 ? | 9.4 | 10.4 |
| " (117658).... | ? | 14.2 | 17.4 | 17.5 | ? | 9.2 | 5.3 |
| " (117659b)... | 14.6 | ? | 16.3 | 12.8 | 2.8 | 8.5 | 6.5 |
| " (117659c)... | ? | 14.0 | 18.0 | 15.7 | ? | 8.5 | 5.5 |

Types.—Holotype: 117659a; figured paratypes: 117658, 117659b,c, 117660a,b; unfigured paratypes: 117659d-g.

Horizon and locality.—Rodman member of Nealmont formation in Pennsylvania: On the old road north of Roaring Spring, Hollidaysburg (15') Quadrangle; 65 feet below top on the Pennsylvania RR. $\frac{1}{2}$ mile north of Roaring Spring, Hollidaysburg (15') Quadrangle; 15 feet below the top in the west end of the quarry at Salona, Lock Haven (15') Quadrangle; 15 and 30 feet below the top in the bluff south of Pennsylvania Highway 44, 150 yards east of the road to Oriole, east of Antes Gap, Williamsport (15') Quadrangle; 5 to 6 feet and 50 to 60 feet below the top in the cut on Pennsylvania Highway 164, 100 yards east of Plum Creek at East Sharpsburg, Hollidaysburg (15') Quadrangle.

Discussion.—The only species to which this one can be compared is *L. brevilingata* from which it differs in having finer wrinkles on the visceral region and a longer frill.

BELLIMURINA Cooper, new genus

(Latin *bellus*, pretty; *murus*, wall)

Shell of moderate size, biconvex in young stages but concavo-convex in the adult. Hinge narrower or wider than the greatest shell width. Cardinal extremities alate to obtuse. Surface marked by costellae of unequal size, the stronger ones separating groups of the smaller ones; in addition to costellae, visceral area of shell marked by zigzag wrinkles. Valves strongly geniculated toward the brachial valve just anterior to the biconvex visceral region. Pseudopunctate.

Pedicle valve with moderately long palintrope, covered delthyrium; pseudodeltidium large, convex; foramen small, apical. Teeth wide and large, dental plates flaring with small umbonal chambers. Delthyrial chamber moderately deep; muscle field wide and short, with a low median adductor ridge.

Brachial valve shallow but with a high and narrow peripheral rim; chilidium strongly convex, arching over a large cardinal process consisting of 2 parts, each with short shaft and myophore showing attachment surfaces for a pair of muscles located on the notothyrial platform. Brachial processes flat blades supported by callus deposited at a low angle to the hinge line. Median ridge short, adductor field small.

Genotype.—*Leptaena charlottae* Winchell and Schuchert, Amer. Geol., vol. 9, p. 288, Apr. 1, 1892.

Discussion.—The members of this genus are not easy to recognize and may be confused with young of *Limbimurina*. The most significant feature of *Bellimu-*

rina is the irregular wrinkling of the visceral region of both valves and the lack of geniculation or the modest development of that feature. *Bellimurina* is quite unlike *Leptaena* in both respects. In the latter genus wrinkling is usually quite uniform, concentric, and strong. Geniculation in that genus, in contrast to this feature of *Bellimurina*, is very strong and often at an angle of about 90° .

The interior of *Bellimurina* is most like that of *Murinella* but lacks the strong subperipheral band in the brachial valve as in the latter genus. The median ridge extending a short distance anterior to the notothyrial platform of *Bellimurina* is somewhat stronger than that feature in *Murinella*.

Bellimurina is generally an uncommon genus and when found is usually identified as *Leptaena charlottae*. The wide identification of this species has misled some authors to age assignments and correlations that are unwarranted. This genus occurs in the Platteville limestone of the upper Mississippi Valley, but the specimens in the National Collection are not suitable for description. In the Southern Appalachians the genus is known from the Pratt Ferry limestone up. Several species are here described on the basis of pedicle valves only because of the fairly distinctive wrinkling of these individuals. The brachial valve is usually not as important for description of species of this genus as the pedicle valve.

A few specimens of *Bellimurina* are known that are as strongly geniculated as most of the members of the genus *Dactylogonia*. These seem to be exceptions. *Bellimurina* is readily distinguished from *Dactylogonia* by its lack of the strong, bladelike adductor plates so characteristic of the latter.

BELLIMURINA CHARLOTTAE (Winchell and Schuchert), 1892

Plate 222, G, figures 11-14; plate 223, H, figures 19-24

Leptaena charlottae WINCHELL and SCHUCHERT, Amer. Geol., vol. 9, p. 288, Apr. 1, 1892; Geol. Minnesota, vol. 3, p. 410, pl. 32, figs. 1-5, 1895.—BASSLER, Cambrian and Ordovician: Maryland Geol. Surv., p. 257, pl. 41, figs. 11-13, 1919.

Strophomena halli, SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 334, pl. 4, figs. 36-38, Apr. 9, 1892.

Types.—Figured hypotypes: Y.P.M. S3619, S3620a,b; U.S.N.M. 45358a.

Horizon and locality.—Decorah formation (*Rhinidictya* bed of the Guttenberg member) in Minnesota: At West St. Paul and Minneapolis.

Discussion.—Some specimens of this species are suggestive of *Dactylogonia* in the form of the pedicle valve and the degree of geniculation. These seem to be exceptions, however, and the majority of specimens are not strongly geniculated.

BELLIMURINA COMPRESSA Cooper, new species

Plate 221, D, figures 23-28

Shell small, biconvex but with brachial valve having the greater depth; wider than long; widest part at about the middle; sides and anterior margins rounded; surface of visceral region marked by oblique, concentric, irregular wrinkles. Alternating costellae cover the entire surface.

Pedicle valve gently convex in lateral profile but with the anterior third somewhat flattened; anterior profile gently convex; median region slightly swollen. Interarea short, strongly apsacline; foramen large.

Brachial valve unevenly convex in lateral profile, the posterior half somewhat flattened but the anterior half gently convex; median region marked by a shallow, irregular sulcus extending from the beak to the anterior margin; flanks bounding sulcus swollen; lateral slopes short and moderately steep.

Measurements in mm.—Holotype, length 8.5, brachial length 8.4, midwidth 10.8, hinge width 9.0, thickness 2.8.

Type.—Holotype: 117653.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: From the top of the green shale on the east side of the cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County.

Discussion.—This species is characterized by its small size and the compressed, biconvex form. It is suggestive of *B. subquadrata* but is a smaller and differently shaped species. Furthermore, the wrinkling of the two species is quite different. *Bellimurina compressa* is marked by finer wrinkles, particularly in the marginal regions, than *B. subquadrata*.

BELLIMURINA CONCENTRICA Cooper, new species

Plate 222, A, figures 1, 2

Shell of about usual size for the genus, wider than long and with the hinge forming the greatest width. Sides gently oblique; anterior margin rounded. Pedicle valve gently convex in both profiles; umbo somewhat swollen; antero-median region marked by a shallow depression. Umbonal and posterior region marked by fine interrupted wrinkles; anterior and lateral areas marked by strong, discontinuous wavy wrinkles. Brachial valve gently convex.

Measurements in mm.—Holotype, length 9.8, midwidth 14.4, hinge width 15.4, thickness 1.9?

Type.—Holotype: 117650.

Horizon and locality.—Pierce formation in Tennessee: At Pierce Mill, on Stone River at crossing with Tennessee Highway 10 just south of Walterhill about $7\frac{1}{2}$ miles north of Murfreesboro, Rutherford County.

Discussion.—This is a fairly large species definitely suggestive of *Leptaena* but not strongly geniculated. The umbonal and median regions are marked by the short, interrupted wrinkles characteristic of *Bellimurina*. The strength of the wrinkles of this species suggest *B. subquadrata*, but concentric wrinkles of the lateral and anterior region are much stronger and more regular. No other described species is really very close to this one.

BELLIMURINA PARVIPLICIFERA Cooper, new species

Plate 222, B, figure 3; plate 223, C, figures 5, 6

Shell moderately large for the genus, wider than long and with the hinge forming the widest part; sides rounded, somewhat oblique; surface marked by

fine costellae undulating over interrupted wrinkles that give the surface a fine dictyate appearance. Pedicle valve slightly convex in lateral profile; broadly and gently convex in anterior profile; margin narrowly geniculated toward the brachial valve to produce a short trail.

Brachial valve gently convex in both profiles; anterior and lateral margin marked by a narrow concave rim corresponding to the anterior geniculation. Interior with delicate cardinalia, the cardinal process small and stout, the median ridge narrow and extending for about one-third the length.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-----------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 11.6 | ? | 18.0 | 19.7 | 1.5 ? |
| Paratype (brachial valve) | ? | 12.2 | 17.4 | 15.0 | ? |

Types.—Holotype: 117652; figured paratype: 117651.

Horizon and locality.—Lebanon formation in Tennessee: On U. S. Highway 41, 9.6 miles southeast of Murfreesboro, Rutherford County; Columbia, Maury County.

Discussion.—This species is known from two specimens only, but the characteristics are strong. It is similar to *B. charlottae* in the type of ornamentation, but the wrinkling is much finer, the visceral disk region somewhat longer, and the geniculation more modest and producing a short trail, less steep than that of the Minnesota species.

BELLIMURINA SUBQUADRATA Cooper, new species

Plate 222, H, figures 15-18

Shell of about average size for the genus, with the hinge forming the greatest shell width and the cardinal extremities slightly alate. Sides nearly straight, oblique; anterior margin broadly rounded. Entire surface marked by irregular and zigzag wrinkles except at the hinge where 4 or 5 subparallel oblique wrinkles appear. Fine costellae cover the entire surface.

Pedicle valve slightly convex in lateral and anterior profiles; umbo slightly convex and without wrinkles; median region slightly swollen; valve sloping gently from the median region to the margins; not geniculate at the front. Muscle field large and subcircular in outline.

Brachial valve gently convex in profile with the most convex part slightly anterior to the middle. A slight median depression extended from the umbo to the anterior margin. On each side of this and in the front half the valve is slightly swollen.

Measurements in mm.—

| | Length | Width | Hinge width | Thickness |
|---|--------|-------|-------------|-----------|
| Holotype (pedicle valve) | 6.7 | 7.8 | 9.6 | ? |
| Paratype (brachial valve 117655b) . . . | 7.1 | 9.9 | 10.6 | ? |

Types.—Holotype: 117655a; figured paratypes: 117655b-d; unfigured paratype: 117655e.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: Slightly north of the middle of sec. 32, T. 2 S., R. 2 E., 2 to 3 miles northeast of Springer, Carter County.

Discussion.—This species is characterized by the strength and variety of its wrinkling. The marginal regions are characterized by stronger wrinkling than in the umbonal and median regions. Some of the wrinkles are chevron shaped so that the ornamentation suggests that of *Ptychoglyptus*. No other species is marked like this one. Under *B. concentrica* a brief comparison is made to this species, but the Pierce form has much stronger and more regularly concentric wrinkles in the marginal zone.

A fragmentary pedicle interior shows that this species attains a size greater than the figured types. This specimen has a length of 11 mm. and the width is indicated as 14 mm. The specimen shows no signs of geniculation at this length.

BELLIMURINA SULCATA Cooper, new species

Plate 223, A, figures 1-3

Shell of about medium size for the genus, slightly longer than wide; hinge about equal to the width at the middle; sides gently rounded; anterior margin somewhat narrowly rounded. Surface marked by small irregular wrinkles on the visceral region and fine costellae that cover wrinkles and trail.

Pedicle valve unevenly convex, the posterior half flattened and the anterior half convex; maximum depth located just anterior to the middle; anterior profile broadly and moderately domed. Visceral region separated from trail by a narrow, shallow groove. Trail anterior to groove long, convex, and with a steep anterior slope.

Measurements in mm.—Holotype, length 11.5, midwidth 13.9, hinge width 13.0, thickness 2.7.

Type.—Holotype: 117654.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This is a fairly convex form and unlike most members of the genus is marked by a long and prominent trail. The visceral region is separated from the trail by a shallow sulcus; the trail extends from the anterior rim of the sulcus. This species differs from all other *Bellimurina*s in the features named and in the long convex trail. The features described are suggestive of *Limbimurina*, but the curved sulcus anterior to the visceral disk is not so deep and the strong element of geniculation toward the pedicle valve is not developed.

BELLIMURINA sp. 1

Plate 222, D, figure 5

This is a moderately convex species known only from the pedicle valve. It is characterized by irregular wrinkles and a slight anterior peripheral depression.

Measurements in mm.—117657a, length 11.0, width 12.6.

Figured specimen.—117657a.

Horizon and locality.—"Ottosee" (= Benbolt?) formation in Virginia: On U. S. Highway 19, $2\frac{1}{2}$ miles west of Paint Lick, Tazewell (15') Quadrangle.

BELLIMURINA sp. 2

Plate 222, F, figure 10

This is a fairly well preserved brachial interior showing the cardinalia, two adductor ridges, and a short median ridge. The specimen is thought to be from the Wardell formation, and its locality is 2 miles west of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle, Virginia.

Figured specimen.—Columbia Univ. 25873.

Family CHRISTIANIIDAE A. Williams, 1953

Smooth or finely costellate Strophomenacea having 4 prominent septa in the brachial valve.

Genus CHRISTIANIA Hall and Clarke, 1892

Christiania HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 298, 1892.

Shells subquadrate to longitudinally subrectangular with the hinge wider or narrower than the width at the middle; pedicle valve strongly convex; brachial valve more or less deeply concave. Surface marked by fine concentric lines, rarely by fine costellae, and fine growth undulations.

Pedicle valve: Interarea longer than the brachial one, curved; delthyrium more or less closed by an elevated, convex pseudodeltidium; foramen small, located at the beak and cutting the beak and the extreme apex of the pseudodeltidium as in the true Strophomenoidea.

Teeth moderately small, wide, and short and with small fossettes. Dental plates nearly obsolete, usually visible as stout ridges under the teeth. Diductor impressions linguulate, confined to the delthyrial cavity which is very deep because of the strongly swollen umbo. Adjustor scars small, somewhat triangular and situated just under the dental plates. Adductor scars small and located at the posterior of the muscle field just in front of the foramen. Diductor impressions surrounding the adductors anteriorly and separated from one another by a more or less well defined median ridge. Major pallial trunks extending from the anterior end of the diductor scars directly anteriorly. About a third the length from the anterior margin these trunks branching and sending secondary trunks in an anteromedian direction. Further branching into tertiary and quaternary sinuses taking place near the anterior margin.

Brachial valve: Brachial interarea twisted into a hypercline position and much shorter than that of the pedicle valve. Chilidium strongly convex and well covering the posterior and brachial face of the cardinal process. Brachiophores widely divergent, moderately long, having the form of a flattened rod with an acute free extremity; brachiophores supported by shell substance deposited on their inner faces. Sockets wide and shallow, partially formed by the sloping outer face of

the brachioophore. Cardinal process bipartite; shafts short, stout, attached to floor of valve; myophores with 2 or more ridges.

Interior of brachial valve divided into unequal parts, a posterior portion occupying about one-third the length and an anterior portion occupying the remainder. Posterior third including the adductor field usually bent at an angle to the anterior portion which probably carried the lophophore. In front of the shafts of the cardinal process 2 ridges originate and extend anteriorly, rising to a crest at the point of geniculation between the anterior and posterior portions of the valve. From the point of geniculation these ridges extend almost to the margin, then curve laterally by a narrow loop and swing posteriorly. At the geniculation they again rise to a crest and extend posteriorly to end under the brachioophores. These ridges are strongly elevated where they bound the adductor field. At the line of geniculation more or less prominent callosities are developed in front of the anterior adductor impressions. In some specimens these callosities may be produced into projecting processes. The adductor scars are obliquely placed, the anterior pair lying in the anteromedian corner of the field and the other pair outside in the posterolateral corner.

Genotype.—*Laptaena subquadrata* Hall, 2d Ann. Rep., New York State Geol., pl. 46, figs. 32, 33, 1883.

Discussion.—This genus has not lately been subjected to a careful study. The result is that a number of species have been placed in it that do not belong. *Christiania lamellosa* Bassler from the Oranda formation of Virginia and Pennsylvania and *C. youngiana* (Davidson) from the Stinchur limestone of the Girvan District, Scotland, must be excluded. These two species have been removed to the genus *Bimuria* Ulrich and Cooper.

CHRISTIANIA AURICULATA Cooper, new species

Plate 215, D, figure 13; plate 215, F, figures 20-28

Christiania trentonensis brevis BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 109, pl. 95, figs. 2, 3 (not 1 = *Bimuria lamellosa*), 1942.

C. cf. C. trentonensis BUTTS (not Ruedemann), idem, figs. 4-6.

Shell of about usual size for the genus, longer than wide; elongate, subrectangular in outline with the sides usually somewhat concave inward or subparallel. Anterior margin narrowly rounded to subnasute; hinge usually as wide as or slightly wider than the midwidth. Cardinal extremities moderately auriculate. Surface marked by more or less regular concentric growth lines.

Pedicle valve strongly convex in lateral profile with the maximum curvature located at the umbo; anterior profile narrowly convex and with precipitous sides. Umbo strongly swollen and protruding posterior to the posterior margin; median region strongly but narrowly swollen; sides nearly vertical; interarea long; anacline. Pseudodeltidium short, wide, and strongly convex.

Brachial valve narrowly and deeply concave, most concave near the middle; sides and anterior margins strongly bent toward the brachial direction; interior with strong ridges; adductor field bordered anteriorly by a strong, transverse ridge. Cardinal process moderately large.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 15.0 | 11.9 | 9.3 | 9.4 | 4.3 | 7.4 |
| Paratype (97536a) | 9.0 | ? | 9.7 | 10.7 | ? | 2.2 |
| " (97536b) | 10.5 | ? | 9.1 | 9.5 | ? | 4.3 |
| " (111005b) | 13.5 | 10.0 | 9.7 | 9.4 | 4.5 | 7.1 |
| " (117570) | 16.9 | 13.1 | 11.5 | 10.6 ? | 5.6 | 8.0 |
| " (117571) | 14.8 | 11.5 | 10.9 | 10.1 | 3.8 | 7.3 |
| " (117572a) | 18.1 | 13.9 | 11.4 | 11.7 | ? | 9.6 |

Types.—Holotype: 97537a; figured paratypes: 97537b, 111005b, 117570, 117571; figured cotype of *C.t. brevis* Butts: 97536b; unfigured cotype *C.t. brevis* Butts: 97536a; unfigured paratypes: 97537c, 111005a, 117572a-c.

Horizon and locality.—Oranda formation in Virginia: Along the railroad $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle; 200 yards on Virginia County Highway 616, southeast of U. S. Highway 11, 3.5 miles southwest of Mount Jackson, Mount Jackson (15') Quadrangle; junction of Virginia County Highways 691 and 692, west of Lantz Mills, Edinburg (15') Quadrangle; on Virginia Highway 55, 0.4 mile west of U. S. Highway 11, on the north edge of Strasburg, Strasburg (15') Quadrangle; just east of the junction of Virginia County Highways 617=910, and 777, $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle; on U. S. Highway 11, $\frac{1}{2}$ mile southwest of Tumbling Run, southwest of Strasburg, Strasburg (15') Quadrangle; at the dam on Shenandoah River, $1\frac{1}{2}$ miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle; Bowman Farm, east side of U. S. Highway 11, 1 mile southwest of Woodstock, Edinburg (15') Quadrangle.

Discussion.—This species is characterized by its elongate form, somewhat concave sides, presence of distinct ears on the cardinal extremities, and its considerable depth. It differs from *C. platys* in its greater depth and different shape. From *C. subquadrata* it differs in generally attaining a greater size, in being somewhat more elongate, and in having definite and fairly prominent ears on the cardinal extremities.

A brachial interior of this species compared to the single interior known of *C. trentonensis* shows general similarity, but the Oranda specimen is more convex. As presently understood the European species *C. tenuicincta* (McCoy) includes too wide a range of variation for accurate comparison with the American species. *Christiania oblonga* (Pander) is a much smaller and more slender species.

CHRISTIANIA PLATYS Cooper, new species

Plate 210, D, figure 11; plate 214, B, figures 3-5; plate 215, B, figures 5-10;
plate 215, G, figure 29

Shell large and broad for the genus, subquadrate in outline and with the length and width nearly equal; sides nearly parallel; anterior margin broadly rounded; hinge nearly equal to the width, slightly auriculate. Surface marked by concentric growth lines only.

Pedicle valve moderately convex in lateral profile and with the maximum convexity in the umbonal region; anterior profile broadly convex with moderately steep sides; umbo swollen posterior to the posterior margin; median region strongly swollen; posterolateral areas slightly auriculate; posterolateral slopes steep; anterior slope moderately steep. Interarea long. Interior unknown.

Brachial valve broadly concave, greatest concavity near the middle; sides not strongly incurved. Interior with prominent septal ridges; adductor field marked by transverse plates uniting the septa about one-third the length from the beak; cardinal process small; chilidium short.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 13.0 | ? | 12.9 | 9.8 | ? | 4.1 |
| Paratype (111011a)... | 11.0 | ? | 10.4 | 10.2 | ? | 3.6 |
| " (111004).... | ? | 12.4 | 12.4 | 10.1 | ? | ? |

Types.—Holotype: 111011b; figured paratypes: 111004, 111007, 111011a, 117573, 117574; figured specimen: 117575.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Strasburg (15') Quadrangle, Virginia: Small glen at the switch about $\frac{1}{8}$ mile east of Strasburg Junction; quarry $\frac{1}{4}$ mile east of the railroad station at Strasburg Junction; south side of the road 0.2 mile east of Strasburg Junction; Edinburg formation, $1\frac{1}{2}$ miles south of Wadesville, Winchester (15') Quadrangle.

Edinburg formation (*Nidulites* zone) in Strasburg (15') Quadrangle, Virginia: 100 yards south of the Battlefield Crystal Caverns entrance on U. S. highway 11, Hupp Hill, 1 mile north of Strasburg; along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg.

Little Oak formation in Alabama: $\frac{1}{2}$ mile north of the bridge on U. S. Highway 31, Pelham, Bessemer Iron District (15') Quadrangle.

Discussion.—This species is distinguished from the others described herein by its quadrate form and generally low convexity. The brachial valve is similar to that of *C. trentonensis* in its low convexity, but it is a wider species than the Rysedorf one. *Christiania platys* is quite unlike either *C. tenuicincta* (McCoy) or *C. oblonga* (Pander).

CHRISTIANIA SUBQUADRATA (Hall)

Plate 214, C, figures 6-8; plate 214, D, figures 9-39; plate 215, C, figures 11, 12; plate 215, E, figures 14-19; plate 221, B, figures 7-15

Leptaena subquadrata HALL, 2d Ann. Rep., New York State Geol., pl. 46, figs. 32, 33, 1883.

Christiania subquadrata (Hall) HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 298, 351, pl. 15, figs. 32, 33; plate 15A, fig. 36; pl. 20, figs. 18-20, 1892; 48th Ann. Rep. New York State Mus., vol. 2, p. 351, pl. 6, figs. 13-18, 1895; 14th Ann. Rep. New York State Geol. for 1894, p. 351, pl. 6, figs. 13-18, 1897.

Christiania trentonensis BUTTS (not Ruedemann), Alabama Geol. Surv., Special Rep. 14, p. 116, pl. 26, figs. 22-24, 1926.

Variable, attaining a length of about $\frac{1}{2}$ inch; elongate oval to longitudinally subrectangular; sides subparallel to slightly divergent; anterior margin nar-

rowly rounded. Valves concavo-convex. Maximum width usually in the anterior third. Surface marked by strong concentric lines of growth and minute, difficultly distinguishable radial lines which cancellate the delicate lines of growth.

Pedicle valve moderately convex in lateral profile but with the umbonal region narrowly and strongly convex; anterior profile narrowly convex and with the sides nearly vertical or very steep and the median region narrowly rounded; umbo swollen; interarea long, strongly anacline; pseudodeltidium short, strongly convex. Interior with dental plates reduced to ridges; vascula media deep and prominent, breaking into distributaries at the anterior third.

Brachial valve deeply concave, the greatest depth located just anterior to the umbo; sides strongly bent toward the brachial valve, anterior less strongly bent. Interior with flat brachiophores; small cardinal process; median pair of ridges strong; lateral ridges somewhat less strong.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Hypotype (117580a).... | 13.2 | 8.8 | 9.4 | 7.3 | 4.9 | 7.8 |
| " (117580b).... | 13.6 | 9.5 | 8.6 | 6.6 | 4.5 | 6.7 |
| " (117580c).... | 15.0 | 10.6 | 10.6 | 8.5 | 4.3 | 7.9 |
| " (117580d).... | 15.0 | 11.1 | 10.0 | 7.7 | 5.0 | 8.0 |
| " (117580e).... | 12.4 | 9.3 | 10.0 | 8.0 | 3.5 | 6.6 |
| " (117580f).... | 11.4 | 9.4 | 9.3 | 7.2 | 3.0 | 6.0 |
| " (117580g).... | 8.7 | 7.0 | 7.7 | 6.1 | 2.1 | 4.8 |
| " (117580h).... | 8.2 | 6.3 | 7.1 | 6.4 | 2.0 | 3.9 |
| " (117580i).... | 5.8 | 5.3 | 6.8 | 6.9 | 1.3 | 2.7 |
| " (111006).... | 12.3 | ? | 8.5 | 7.3 ? | ? | 4.6 |
| " (71501)..... | 13.7 | 10.7 | 11.0 | 8.6 | 3.7 | 6.4 |
| " (111016a).... | 12.0 | 8.9 | 9.0 | 7.0 | 3.6 | 5.8 |
| " (111016b).... | 13.6 | 9.4 | 7.9 | 6.8 | 4.1 | 6.8 |
| " (117578)..... | 10.3 | 7.8 | 8.4 | 8.4 | 4.0 | 6.3 |

Types.—Figured hypotypes: 71501, 110999a, 111013a, 111015, 111016a, 111017b, 111018a,b, 111020a-d, 111021a,c, 111029a, 117578, 117579a, 117580j, 123363, 123266a-g; measured specimens: 111006, 111016b, 117580a-i; figured specimen: 117577.

Horizon and locality.—Little Oak formation in Alabama: $\frac{1}{2}$ mile along Highway 31 northeast of Pelham, Bessemer Iron District (15') Quadrangle; $\frac{3}{4}$ mile northwest of Mosteller, St. Clair County; junction Bailey Gap and Cahaba Valley roads, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

"Lenoir" limestone in Alabama: 20 feet below the Pratt Ferry formation, 0.15 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Pratt Ferry formation in Alabama: Same locality as above.

Arline formation in Tennessee: At the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; on the southeast edge of Friendsville and 1 mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 5 miles southeast of Knoxville; on Kennedy Road, 0.4 mile northwest of Marbledale Church, Shooks Gap (T.V.A. 147-NE) Quadrangle; 1.500

feet south of mouth of Burnett Creek, Shooks Gap (T.V.A. 147-NE) Quadrangle.

Arline formation in Virginia: $\frac{1}{2}$ mile south of McMullen switch, 4 miles southwest of Marion, Marion (T.V.A. 218-SE) Quadrangle.

Athens formation (base) in Tennessee: Just east of the road intersection $2\frac{1}{2}$ miles south-southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle; 600 feet S. 40° E. of the railroad-highway intersection 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-SE) Quadrangle; Tennessee Highway 60, $5\frac{1}{2}$ miles east of Cleveland, East Cleveland (T.V.A. 131-SW) Quadrangle; Craighead Creek, $\frac{1}{4}$ mile north of Christiansburg, Sweetwater (T.V.A. 131-SW) Quadrangle; road along Meadow Fork, east of junction, $2\frac{1}{2}$ miles northeast of Calhoun, Calhoun (T.V.A. 125-SW) Quadrangle.

Fetzer tongue in Tennessee: Bend of the road 1.3 miles south of Sevierville, Pigeon Forge (T.V.A. 156-SE) Quadrangle.

Botetourt limestone in Tennessee: $2\frac{1}{2}$ miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle.

Same in Virginia: Junction of Virginia Highways 311 and 114, $\frac{1}{2}$ mile southwest of Catawba, Salem (15') Quadrangle; 4 miles southwest of Bland, Bland County.

Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Edinburg formation (*Crytonotella* zone) in Virginia: In the ravine at the switch about $\frac{1}{8}$ mile east of Strasburg, Strasburg (15') Quadrangle; near the dam on Shenandoah River, $1\frac{1}{2}$ miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle.

Same formation (*Nidulites* zone) in Virginia: 100 yards south of Battlefield Crystal Caverns entrance on U. S. Highway 11, Hupp Hill, 1 mile north of Strasburg, Strasburg (15') Quadrangle.

Youngman formation in Vermont: In Mississquoi Park, Highgate Springs, St. Albans (15') Quadrangle.

Discussion.—This species is characterized by its longitudinally subrectangular outline, strongly umbonate pedicle valve, deeply concave brachial valve, and generally somewhat broadly rounded front. This species is so unlike *C. platys* in its profiles and outline that further comparison is unnecessary. Its brachial valve appears to be much more concave than that of *C. trentonensis*. The species is most like *C. auriculata*, but it does not have as strong a development of the cardinal extremities as that species, nor does it usually attain the large size of the Oranda species. The lateral margins of *C. subquadrata* are never concave inward and usually vary from nearly parallel to gently divergent anteriorly. The species is thus usually wider at the front than is customary in the Oranda species.

Christiania subquadrata is a very variable species as can be seen from the large collections from Friendsville. At this place it may often be picked up in the dirt by the hundreds, the specimens having been washed by rain from the residual soil resulting from decomposition of the Arline limestone. The Friendsville forms vary from nearly parallel sided to specimens having anteriorly diver-

gent sides. These usually have a moderately to broadly rounded anterior. The expanded front is a feature common to many of the specimens from the Little Oak limestone of Alabama. Some specimens from that formation are more expanded anteriorly than is usual in the variation of the species in Tennessee. Specimens referred to *C. subquadrata* from the lower Edinburg formation of Virginia are generally quite small and deep but appear to be well within the variation of the species.

Some confusion has attended the identification of this genus and species in the United States by the fact that Hall and Clarke incorrectly stated its occurrence as from the Helderberg formation of West Tennessee. These authors added to the confusion by failing to give any indication of the enlargement of their figures 32 and 33 on plate 15. On plate 15, figure 36, the enlargement of the posterior of the brachial interior is indicated as $\times 3$ whereas it is actually $\times 4$. The enlargement of the figures on plate 15 is about $\times 2$.

CHRISTIANIA TRENTONENSIS Ruedemann

Plate 214, A, figures 1, 2

Christiania trentonensis RUEDEMANN, New York State Mus. Bull. 49, p. 21, pl. 2, figs. 2-6, 1901; Virginia Geol. Surv. Bull. 2A, pl. 3, figs. 14-16, 1909.

This species has been widely identified in the Appalachians, but it is doubtful if any of the identifications are correct. The material on which this species was created is too poor to make any identifications with it a certainty. Ruedemann figures a specimen representing both valves. Examination of his figures and casts of the specimens indicates that all the figured specimens are actually brachial valves. Figures 2 and 3 of his plate 2 are stated to be respectively exterior and side views of the pedicle valve. Figure 2 is clearly a brachial valve as indicated by the straight and even hinge line. Furthermore, part of the shell is retained where it has not been exfoliated from the mold of the concave brachial exterior. In his description Ruedemann states: "Pedicle valve uniformly and strongly convex; umbo slightly projecting and very narrow, beak obscure." Figure 2 shows no slightly projecting umbo nor can it be seen in the cast. The profile view (fig. 3) is of the mold of the concave exterior which would have considerable convexity.

In connection with the brachial interior one point needs attention. This is Dr. Ruedemann's description of denticles. No denticles such as he describes were seen in the extensive Appalachian material available for study. The casts of the types show several vertical lines and ridges, but these are located on the place from which the cardinal process has been torn. These are actually not denticles but represent the broken bases of the cardinal process. This feature is shown clearly in figure 6. Here the cardinal process narrows to points with the denticle on the outside. In well-preserved specimens the cardinal process consists of 2 moderately expanded lobes.

Ruedemann prepared his specimens by roasting the limestone pebbles in which they occurred and then plunging them into cold water. This treatment naturally

tears the shells apart and leaves them in too poor condition for good specific description.

The fossils associated with *C. trentonensis* are those of the lower Edinburg or Oranda. *Christiania* is abundant in both of these formations, but it seems impossible to place *C. trentonensis* with either the Edinburg or Oranda species of *Christiania*. In the absence of more detailed information about the pedicle valve accurate comparison is impossible. The brachial interior of a single specimen is not adequate for specific identification of specimens taken from widely different geographic and stratigraphic realms.

Types.—Cotypes: New York State Mus.

Horizon and locality.—Rysedorf conglomerate (pebbles of group 5) in New York: Rysedorf Hill, near Albany.

CHRISTIANIA TRENTONENSIS BREVIS Butts

Plate 215, D, figure 13

Christiania trentonensis brevis BUTTS, Virginia Geol. Surv. Bull. 52, pt. 2, p. 109, pl. 95, fig. 1, 1942.

This species is based on three cotypes. Two of these are young forms of *Christiania auriculata* Cooper, new species, and the other is a fine brachial interior of *Bimuria lamellosa* (Bassler). The writer here selects the latter specimen, 97536a (pl. 95, fig. 1), as lectotype of *C. trentonensis brevis* Butts. This selection makes this species a synonym of *B. lamellosa* (Bassler) and clears the way to establish *C. auriculata* on adult forms.

Figured specimen.—97536b.

Family STROPHOMENIDAE King, 1846

Strophomenacea having either normal or reversed convexity of the valves and a small foramen in the pedicle valve.

Genus KIRKINA Salmon, 1942

Kirkina SALMON, Journ. Paleont., vol. 16, No. 5, p. 599, 1942.

KIRKINA MILLARDENSIS Salmon

Kirkina millardensis SALMON, Journ. Paleont., vol. 16, No. 5, p. 599, pl. 87, figs. 34, 35, 1942.

Types.—Holotype: Columbia Univ. 25917; figured paratype: Columbia Univ. 25918.

Horizon and locality.—Pogonip group, Point of Rocks, Millard County, Utah=Lehman formation (zone N of Hintze).

RHIPIDOMENA Cooper, new genus

(Greek *rhipidos*, fan; *mene* crescent)

Shells generally large, attaining a length of about 2 inches and a width of nearly $2\frac{1}{2}$ inches; generally wider than long, usually somewhat parallel sided;

cardinal extremities subrectangular to subauriculate; convexi-concave in the adult but concavo-convex when young; anterior commissure rectimarginate. Surface finely costellate, strong and fine costellae alternate and appear in several generations; entire surface covered by fine concentric fila. Pseudopunctae finely and densely matted.

Pedicle valve with minute pedicle foramen, pseudodeltidium of moderate size and convexity; teeth small, surface smooth or roughened, supported by callus thickening; muscle area large, occupying about half the valve area; diductor scars broad and flabellate; adductor scars small, located at about the middle of the muscle field on 2 low, subparallel ridges that extend anteriorly to about the valve middle where the diductors end. Posterior of delthyrial cavity filled by adventitious shell. Anterior and lateral margins with thickened inner rim.

Brachial interior with thickened notothyrial platform bearing 2 stout lobes of the cardinal process having short shafts and flat myophore surfaces. Brachio-phores visible as short, flat blades on the inner side of the sockets and nearly buried by adventitious shell material. Median ridge short and low; adductor field marked by 4 short radiating ridges, 2 on each side of the median ridge; moderately thickened rim just inside margins, but not so prominent as that of the pedicle valve.

Genotype.—*Strophomena tennesseensis* Willard, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 285, pl. 2, figs. 17, 18, 1928.

Discussion.—This genus is characterized by gentle geniculation of the valves, quadrate outline, and with length and width nearly equal. Most of the species have the sides nearly parallel. Inside the pedicle valve the muscle field is very large and flabellate, often occupying nearly half the area of the interior. The diductors are commonly separated by 2 parallel ridges that extend from the posterior to the anterior end of the muscle scar. The interior is also marked by a prominent ridge inside the margin. Dental plates are absent, and no marked thickening is laid under the dental ridges which simulates a dental plate as in *Strophomena*.

The brachial valve is characterized by small and delicate cardinalia for such large shells. The median ridge is very short, and the socket cups of adventitious shell formed around the brachio-phore are small. Two short ridges may appear in connection with the adductors on each side of the median ridge.

Rhipidomena is an early strophomenoid which differs from *Strophomena* in its external habit, having a quadrate form and modest geniculation and differing internally in the form of the pedicle muscle region and the thick inner, sub-peripheral rim. In *Strophomena* a ridge of adventitious shell generally nearly surrounds the muscle scars, and the muscle field is proportionately smaller than that of *Rhipidomena*. The brachial interiors of both genera are basically the same.

RHIPIDOMENA FILICOSTELLATA Cooper, new species

Plate 254, B, figures 4-6

Shell of about usual size for the genus, subquadrate in outline and with the length and width nearly equal; hinge narrower than the greatest shell width which

is at the middle; sides gently rounded; anterior margin strongly rounded; costellae fine and delicate, 4 to a millimeter at the front margin. Costellae on posterior half alternating strong and fine, as many as 7 fine costellae separating the strong ones; anterior with costellae not distinctly differentiated.

Pedicle valve gently concave as usual in the genus; muscle region moderately large; ridges extended anterior to dental ridges unusually short.

Brachial valve unevenly convex in lateral profile and with the posterior quarter gently concave and the anterior three-quarters moderately convex; maximum convexity slightly anterior to the middle; anterior profile moderately and broadly convex. Umbonal region gently concave; anterior three-quarters swollen medially; lateral slopes short and steep; anterior slope moderately long and steep; cardinal extremities rounded and deflected in the direction of the brachial valve.

Measurements in mm.—Holotype, length 32.8, brachial length 31.0, midwidth 34.1, hinge width 27.8?, thickness ?.

Type.—Holotype: 117671a; figured paratype: 117671b.

Horizon and locality.—Sevier formation in Tennessee: 1 mile by road northwest of Big Springs, Binfield (T.V.A. 139-NE) Quadrangle.

Discussion.—This species is known from two specimens which reveal the pedicle interior, the brachial exterior, and the interarea of the pedicle valve. The species is most like *R. tennesseensis* but differs notably in its profiles. The lateral profile of *R. tennesseensis* is much more convex in the region of geniculation than the Sevier species. Furthermore, the concave or depressed region from the brachial beak to the place of geniculation is deeper and longer in *R. tennesseensis*. This area in the Sevier species is only depressed for a short distance in the vicinity of the umbo. The median region is marked by a broad swelling rather than a marked geniculation. In anterior profile *R. flicostellata* is gently and broadly convex, but *R. tennesseensis* is strongly domed.

RHIPIDOMENA MESLERI Cooper, new species

Plate 218, C, figures 8-10; plate 249, C, figures 13-17; plate 250, A, figures 1-14;
plate 254, A, figures 1-3

Shell of moderate size for the genus, wider than long with the width about $1\frac{1}{4}$ times the length; semielliptical in outline; cardinal extremities varying from acutely angular to obtuse depending on age, the older specimens having right or obtuse angles. Lateral margins variable but usually straight or nearly so in the adults. Anterior and anterolateral margins broadly rounded. Surface covered by costellae of unequal size; the larger or primary costellae are separated by 1 to 3 finer ones. All costellae widen slightly anteriorly but in some specimens tend toward uniformity in size. In 5 mm. at the front of 2 specimens, 21 and 23 costellae may be counted. Costellae are crossed by elevated fila about 11 to a millimeter at about the middle of a valve 20 mm. long.

Pedicle valve very gently to moderately concave at about the middle; umbonal region very gently swollen; anterior half very gently concave to nearly flat. Cardinal extremities only slightly deflected toward the brachial valve. Lateral

portions gently concave to nearly flat. Interarea short, apsacline. Pseudodeltidium not strongly arched.

Brachial valve unevenly convex in lateral profile, the greatest convexity at about the middle. From the posterior margin the valve rises moderately steeply to the middle where it is abruptly rounded; the anterior slope is moderately steep, somewhat less steep than the posterior slope and is flat in profile. Lateral slopes moderately steep. Umbo marked by a shallow, narrow sulcus equal in length to about a fifth the length of the valve. Cardinal extremities slightly deflected. Interarea short.

Interior of pedicle valve with a roundly elliptical to ovate muscle field having broad subflabellate diductor impressions and adductor impressions on a double median ridge located posterior to the middle of the field. Callosity posterior to muscle field not greatly thickened. Median ridge not extending anterior to the ends of the diductor impressions. Subperipheral ridge not strongly developed. Interior of brachial valve with moderately large cardinal process, small adductor field, and low and short median ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 23.0 | 22.4 | 28.8 | 25.9 | 4.6 |
| Paratype (117678a) | 20.7 | 20.0 | 24.2 | 23.0 | 2.8 |
| “ (117678h) | 18.0 | 17.9 | 21.2 | 23.4 | 3.8 |
| “ (117676) | 27.0 | 26.3 | 32.1 | 35.2 | 3.5 |
| “ (117675a) | 41.4 | 40.7 | 52.0 | 50.4 ? | 5.8 |
| “ (117677) | 31.1 | 30.0 | 39.5 | 39.0 | 4.9 |

Types.—Holotype: 117678b; figured paratypes: 117674a, 117675a, 117676, 117677, 117678a,c,f,g; unfigured paratypes: 117675b, 117678d,e,h.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: North of Hayes' house, Evans Ferry, Howard Quarter (T.V.A. 162-NW) Quadrangle; 0.1 mile north of the road, 0.8 mile southwest of Mount Eager Church, Powder Springs (T.V.A. 154-SW) Quadrangle; Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 0.4 mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; 0.2 mile northwest up lane, $\frac{1}{2}$ mile southwest of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle; southeast side of Library Hill, Dutch Valley (T.V.A. 154-SE) Quadrangle; 2 miles southwest of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; Beaver Creek, Maynardville (30') Quadrangle.

Discussion.—This species is characterized by its somewhat transverse form, which is unusual for the genus, and gentle profiles; it is thus in strong contrast to *R. tennesseensis* and *R. subparallela*. This species differs from *R. tennesseensis* in having its place of geniculation much nearer the brachial umbo, in the gentleness of the geniculation which forms a low, broad, rounded swelling, and in the low convexity and concavity of the valves. From *R. subparallela* the Hogskin species differs in having a more rectangular outline, less narrowly rounded anterior margin, more swollen umbonal and median region on the

pedicle valve, shorter and less concave umbonal region on the brachial valve, and a less sharply geniculated brachial valve.

Rhipidomena mesleri differs strongly from *R. tenuitesta* in having more pronounced and more strongly convex brachial valve, shorter umbonal swelling in the pedicle valve, and more rectangular outline.

RHIPIDOMENA SUBPARALLELA Cooper, new species

Plate 251, A, figures 1-12

Shell attaining a length of slightly over an inch; wider than long and with the hinge forming the widest part; sides subparallel, slightly excavated just anterior to the cardinal extremities. Anterior margin narrowly rounded; profile moderately convexi-concave. Finely costellate; 3 costellae to a millimeter at the front margin.

Pedicle valve unevenly concave in lateral profile, the posterior half gently convex but the anterior half gently concave; umbonal and posterior half of the median region gently swollen; lateral and anterior regions gently concave to nearly flat; interarea moderately long, pseudodeltidium short.

Brachial valve nearly flat in the posterior half of the lateral profile but with anterior half bent abruptly toward the pedicle valve and gently convex. Median region concave; lateral regions and anterior half gently convex and sloping moderately. Interarea short.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 26.8 | 25.8 | 29.3 | 32.1 | 4.6 |
| Paratype (117681a) | 24.8 | 24.2 | 25.6 | 26.8 | 4.0 |

Types.—Holotype: 117679; figured paratypes: 117680a, 117681a,b; unfigured paratypes: 117680b, 117681c,d.

Horizon and locality.—Elway formation in Tennessee: Road cut and quarry on U. S. Highway 25W, 4.7 miles south of Clinton, Powell Station (T.V.A. 137-SE) Quadrangle.

Discussion.—This species is characterized by its quadrate or subrectangular outline, which generally creates the illusion of a shell that is longer than wide. This species is likely to be confused only with *R. tennesseensis*, which it strongly resembles. It differs from the Benbolt species in having less anterior convexity and less pronounced geniculation.

Rhipidomena subparallela is more strongly geniculated than *R. tenuitesta* as it has a much more pronounced strophomenoid form than the Hogskin-Lincolnshire species.

RHIPIDOMENA TENNESSEENSIS (Willard)

Plate 252, A, figures 1-5; plate 252, B, figures 6-14; plate 253, A, figures 1-14

Strophomena tennesseensis WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 285, pl. 2, figs. 17, 18, 1928.

S. amploides BUTTS, Virginia Geol. Surv. Bull. 52, pl. 87, figs. 7-12, 1942.

Shell large for the genus, varying in outline from nearly quadrate to semielliptical. Cardinal extremities deflected toward the brachial valve varying from a

right angle to alate. Hinge equal to or greater than the width at the middle. Lateral margins varying from nearly straight to oblique to greatly rounded. Anterior margin narrowly to broadly rounded. Surface ornamented by fine radiating costellae of 2 sizes, 1 or 2 costellae separating the larger ones. On the lateral slopes, particularly anterior to the cardinal extremities, the costellae become fairly uniform in size. Finer radii increasing in size toward the anterior margin and tending toward uniformity in size along the margin. At the front margin of a specimen 33 mm. long, 25 costellae may be counted in 5 mm., but in a specimen measuring 46 mm. in length, only 16 costellae were counted in the same distance. Entire surface covered by fine concentric fila, about 8 or 9 in a millimeter at about the middle, becoming more crowded toward the front. Hinge region may or may not be marked by a few oblique wrinkles.

Adult pedicle valve with posterior half gently swollen and with gentle slopes; anterior half moderately strongly geniculated toward the pedicle valve; geniculation of lateral portions more gentle. Angle of geniculation between 105° and 130° . Beak inconspicuous; foramen small, elongated, often at the anterior of a short groove. Interarea moderately long, apsacline. Pseudodeltidium low and inconspicuous.

Posterior half of brachial valve flattened, gently concave at the umbo; anterior slope moderately steep; lateral slopes steeper than the anterior one. Umbonal region sulcate, sulcus wide and shallow, extending nearly to middle of valve.

Interior: Muscle area of pedicle valve broadly cordate; diductor scars flabellate, separated by 2 low ridges. Adductor scars elongate elliptical in outline, located somewhat posterior to the middle of the muscle area. Delthyrial chamber filled by callus that is extended forward as far as the posterior ends of the adductor impressions.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (117683a)..... | 47.0 | 46.0 | 59.6 | ? | 7.8 |
| " (98202b)..... | 52.2 | 51.7 | 58.3 | 63.4 | ? |
| " (117685)..... | 40.8 | 39.8 | 46.0 | 49.0 | 6.7 |
| " (98202a)..... | 33.2 | 32.0 | 35.7 | 38.5 | 7.0 |
| " (117684a)..... | 27.2 | 26.8 | 28.2 | 29.3 | 3.7 |
| " (117694a)..... | 37.8 | 37.0 | 44.0 | 41.2 | 7.5 |
| " (117694f)..... | 18.9 | 18.1 | 21.0 | 21.0 | 2.3 |

Types.—Figured hypotypes: 117682a, 117683a, 117684a, 117685, 117686, 117687, 117688, 117691a, 117692a, 117694a,b; measured hypotypes: 98202a,b, 117694f.

Horizon and locality.—Benbolt formation in Tennessee: In road cuts 0.9 and 1.6 miles northeast of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle; $\frac{3}{4}$ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle; Liberty Hill, north of Luttrell, Dutch Valley (T.V.A. 154-SE) Quadrangle; 0.1 to 0.2 mile north of the road, 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; 30 feet above the marble on the road along Little Sycamore Creek, $\frac{1}{2}$ mile northeast of the west

edge of the Howard Quarter (T.V.A. 162-NW) Quadrangle; $\frac{1}{2}$ mile northeast of Halls School, behind the marble cliff, Howard Quarter (T.V.A. 162-NW) Quadrangle; Lone Mountain to Tazewell road, $1\frac{1}{2}$ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; 1 mile west of Lone Mountain, same quadrangle; 200 feet above the "Mosheim" at the east foot of the third ridge, Loyston Pike toward Maynardville; Raccoon Valley just east of Edgemoor, 3.1 miles southwest of Claxton, Clinton (T.V.A. 137-SW) Quadrangle; $\frac{1}{2}$ mile west of Dodson Creek on the road from Acuff to Tennessee Highway 33, Powder Springs (T.V.A. 154-SW) Quadrangle; west side, 1 mile from crest of Missionary Ridge, Chattanooga, Chattanooga (30') Quadrangle.

Same formation in Virginia: At Rye Cove and vicinity, Clinchport (T.V.A. 188-NW) Quadrangle; Virginia Highway 71 between Mason's store and Dickensonville, Hansonville (T.V.A. 205-SW) Quadrangle; 0.2 mile southwest of New Bethel Church, $\frac{1}{2}$ mile east of the junction of Virginia Highway 74 and U. S. Highway 54, Hilton (T.V.A. 197-NW) Quadrangle; Fugates Hill 2 miles N. 54° W. of Mendota, Bristol (30') Quadrangle; 1 mile southeast of Hansonville, Brumley (T.V.A. 205-SE) Quadrangle; 4 miles east-northeast of Gate City, Gate City (T.V.A. 188-NE) Quadrangle; $\frac{1}{4}$ mile southeast of Green Valley Church, Brumley (T.V.A. 205-SE) Quadrangle; south side of Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles due south of Hansonville, Hansonville (T.V.A. 205-SW); $\frac{1}{2}$ mile northeast of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; north of Copper Creek bridge, $1\frac{1}{2}$ miles southeast of Nicklesville, Bristol (30') Quadrangle; north side of Virginia Highway 74, $\frac{1}{2}$ mile west of Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; $\frac{3}{4}$ mile east-northeast of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle.

Discussion.—This species is often abundant in the Benbolt and is an excellent guide to that formation. The species is variable, but generally it is nearly square to subrectangular and is fairly strongly geniculated. It is the most strongly geniculated known member of this genus. The abrupt swelling of the anterior about two-thirds the length from the beak is a well-marked characteristic. The species varies considerably in size, and the larger the individual becomes, the more it increases its width.

The only known species close to *R. tennesseensis* are *R. filicostellata* and *R. subparallela*. From the former *R. tennesseensis* may be distinguished by its stronger geniculation and deeper brachial umbonal region. From the latter it differs in stronger geniculation, less deeply concave brachial umbo, and geniculation taking place nearer the brachial umbo.

RHIPIDOMENA TENUITESTA (Willard)

Plate 251, B, figures 13-17; plate 251, C, figure 18

Strophomena tenuitesta WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 287, pl. 2, figs. 15, 16, 1928.

Shell large, width slightly greater than the length; greatest width anterior to the hinge; sides gently rounded; anterior margin strongly rounded; surface marked by alternating costellae, 2 to 4 to the millimeter at the front margin.

Pedicle valve unevenly convex in lateral profile, the posterior third gently convex, the anterior two-thirds nearly flat; anterior profile broadly but gently convex and with the median region somewhat humped; umbonal region and median third gently swollen to form a low but perceptible median fold, visible nearly to the front margin. Flanks long and gently sloping; anterior slope long and gentle; interarea moderately long, gently apsacline. Pseudodeltidium small and wide. Muscle field nearly circular, large; subperipheral rim narrow and elevated.

Brachial valve nearly flat in lateral profile but with the posterior third flat and the anterior two-thirds gently convex; anterior profile broadly and slightly convex; umbo and median posterior third gently concave; flanks and anteromedian two-thirds flat or perceptibly convex. Interior unknown.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thickness |
|----------|----------------|--------|-----------------|----------|-------------|-----------|
| Hypotype | (117697a)..... | 41.7 | ? | 45.1 | 49.2 ? | ? |
| " | (117697b)..... | 36.6 | 35.4 | 43.5 | ? | 6.8 |
| " | (117696)..... | 45.4 | ? | 50.3 | 47.0 ? | ? |

Types.—Figured hypotypes: 117695c, 117696, 117697a,b.

Horizon and locality.—Lincolnshire formation (Hogskin member) in Tennessee: At Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; Evans Ferry section, U. S. Highway 25E, north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle.

Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile north and northwest of Eidson, Kyles Ford (170-SE) Quadrangle.

Same formation in Virginia: At Clinchport, Clinchport (T.V.A. 188-NW) Quadrangle; Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; on U. S. Highway 19, 0.3 mile east-southeast of Hansonville Post Office, Hansonville (T.V.A. 205-SW) Quadrangle; north of Copper Creek on the railroad between Speers Ferry and Clinchport, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This is a large species characterized by its gentle curves in lateral profile, the swollen umbonal region, and moderately strong costellae. It is closest to *R. tennesseensis* but is readily distinguished by its depressed form and different proportions, the length and width being nearly equal. It is a larger species than *R. subparallela* but is not so strongly convex in the anterior part of the brachial valve as that species.

RHIPIDOMENA sp. 1

Plate 213, D, figures 23, 24; plate 248, B, figures 2, 3

Three imperfect specimens are the only trace of this genus yet to be taken from the Arline formation. These indicate a subquadrate species of low convexity and concavity. The posterior half of the pedicle valve is convex and the anterior half very gently concave. The umbo is fairly strongly swollen, but the swelling dies down at the middle of the valve. The umbo of the brachial valve is marked by a narrow, shallow sulcus that extends to about the middle of the valve. The posterior third of the brachial valve is somewhat flattened, but the

remainder is gently convex. The surface is marked by fairly strong costellae, about 15 in 5 mm. at the anterior margin. Fine costellae alternate with several of the stronger ones.

Measurements in mm.—117699a, length 23.9, brachial length 22.5, midwidth (based on half-width) 27.4, thickness 4.9.

Figured specimens.—117698, 117699a.

Horizon and locality.—Arline formation in Tennessee: About 100 feet below the top in the glade $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—The specimens are not like any described species.

Genus *TRIGRAMMARIA* Wilson, 1945

Trigrammaria WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 140, 1945; Geol. Surv. Canada, Bull. 8, p. 108, 1946.

The description by Dr. Wilson is as follows: "The species and its varieties, like *Strophomena* have a resupinate pedicle valve, concave anteriorly, and a convex brachial valve. They are triangular in outline; the brachial valve being more or less sharply geniculate with a broad anterior fold prolonged beyond the general contour, and a corresponding sinus in the pedicle valve; a small pedicle muscle scar and three septa in the brachial valve; the median septum is prolonged and two lateral ones added, both curving inward towards the median septum; pseudopunctae forming a fine irregular network.

"The genotype of *Strophomena*, *S. rugosa* cannot now be examined. The first *Strophomena* described and illustrated from North America was *Producta incurvata* Shepard, 1838, now recognized as *S. filitexta* Hall. This species illustrates the typical form, the deeply sculptured pedicle muscle scar and a single strong median septum, and the radial arrangement of the punctae, and it is here regarded as typical of the genus *Strophomena*.

"Several score of *S. filitexta* were examined, none of them complete, but all showed one stout median septum or its impression. *Trigrammaria* differs, then, from *Strophomena* in having three septa in the brachial valve, in its small pedicle muscle scar, and in the irregular network arrangement of the [pseudo] punctae. It differs from the following genus *Microtrypa* in being triangular in outline and in being convex and more or less geniculate. In addition, the median septum of *Microtrypa* divides anteriorly making 4 septa in all.

"The name is derived from tria (three) and gramme (a line) and refers to the three fine septa."

Strophomena winchelli Hall and Clarke is referred to this genus because of the brachial folding and triseptate interior of the brachial valve.

TRIGRAMMARIA TRIGONALIS PRIMA Wilson

Trigrammaria trigonalis prima WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 143, pl. 2, figs. 3, 4, 1945; Geol. Surv. Canada, Bull. 8, p. 110, pl. 10, fig. 20, 1946.

Type.—Holotype: G.S.C. 7658.

Horizon and locality.—Chaumont formation in Quebec; La petite Chaudière, west of Hull.

TRIGRAMMARIA WILSONAE Cooper, new species

Plate 263, B, figures 10-16

Shell of about medium size for the genus, subrectangular in outline; wider than long and with the hinge narrower than the width at the middle; sides gently rounded; anterior margin subnasute; anterior commissure narrowly uniplicate; surface finely costellate, strong costellae alternating with up to 4 fine costellae.

Pedicle valve uneven in lateral contour, the umbonal region gently convex but the anterior three-fourths gently concave; anterior profile broadly and gently concave; umbonal region gently convex; median region marked by a shallow and narrow sulcus that deepens toward the anterior margin; flanks bounding sulcus gently concave; sides slightly bent in the direction of the pedicle valve.

Brachial valve gently convex in lateral profile and with the maximum convexity at about the middle; anterior profile broadly and moderately convex; beak marked by a smooth swollen spot; umbo marked by a shallow, narrow sulcus that disappears at about the valve middle; median region swollen, the swelling extending to the lateral slopes which are short and steep; median fold originating just anterior to the middle, narrowly rounded.

Measurements in mm.—Holotype, length, 14.3, brachial length 13.9, midwidth 16.9, hinge width 14.9, thickness 4.5, height 4.7.

Type.—Holotype: 117753.

Horizon and locality.—Rockland formation (Napanee member) in New York: From a road cut on the east side of New York Highway 12 on the south side of Sugar River, $4\frac{1}{2}$ miles south-southeast of Port Leyden, Port Leyden (15') Quadrangle.

TRIGRAMMARIA WINCHELLI (Hall and Clarke)

Plate 263, A, figures 1-9

Strophomena winchelli HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 344, pl. 9, figs. 10, 12-14, 1892.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, pt. 1, p. 394, pl. 31, fig. 11, 1895.—HALL and CLARKE, 48th Rep. New York State Mus., vol. 2, 1895, p. 344, pl. 4, figs. 31-33, 1895; 14th Rep. State Geol. New York for 1894, p. 344, pl. 4, figs. 31-33, 1897.—RAASCH in SHROCK and RAASCH, Amer. Midland Nat., vol. 18, No. 4, p. 492, pl. 4, fig. 10, 1937.

Types.—Figured hypotypes: 117752a,b, 123280.

Horizon and locality.—Platteville formation (McGregor member) in Minnesota, Wisconsin, and Illinois.

FURCITELLA Cooper, new genus(Latin *furca*, fork)

Shells small, attaining a width of about 0.8 inch; generally wider than long; subrectangular in outline, with the hinge generally equal to or slightly less than the midwidth. Biconvex, but the valves unequal in convexity, the brachial valve having the greater convexity and the pedicle valve usually flattened to somewhat concave in the anterior half. Surface costellate, costellae subequal. Foramen large; pseudodeltidium strongly convex. Pseudopunctate.

Interior of pedicle valve with large, stout teeth, short but stout dental plates; muscle field moderately large, subcircular, surrounded by a thin to moderately thick extension from the dental plates that nearly surrounds the area. Diductor scars crescentic, large; adductor scars small, divided by a short median ridge; no pallial marks preserved in specimens available.

Interior of brachial valve with short, stout cardinal process, convex chilidium, and moderately thickened notothyrial platform; brachiophores thin and bladelike, supported by cups of adventitious shell; median ridge short and low, bifurcating anteriorly; adductor scars elongate, separated by an oblique ridge on each side of the median ridge. Pallial sinuses consisting of 4 parallel trunks extending directly anterior to the adductor field.

Genotype.—*Furcitella plicata* Cooper, new species.

Discussion.—This genus is characterized by its fairly strong and even costellae, the compressed biconvex form with only the anterior of the pedicle valve flattened to concave; fairly large foramen; rounded muscle scar in the pedicle valve surrounded by extensions from the dental plates; short dental plates; strophomenoid cardinalia but with median ridge forked at the front and with an oblique lateral ridge on each side of it.

Unlike *Strophomena* the genus *Furcitella* appears to have definite dental plates. These appear in young specimens in which the margins of the muscle area not yet thickened. Close examination of such specimens shows that the dental plate is directly under the dental ridge and not offset from it. The structures have exactly the appearance of the receding dental plate so characteristic of the orthids.

The members of this genus have been previously assigned to *Holtehdahlina* of Foerste. The external resemblance between the two genera is very close. *Holtehdahlina* is characterized by a compressed biconvex profile, large foramen, subequal and strong costellae but the interior is essentially that of *Strophomena*. Inside the brachial valve of *Holtehdahlina* the median ridge does not bifurcate as in *Furcitella*, but 2 ridges arise on each side of it near its anterior end. This arrangement simulates bifurcation but is certainly not the same.

Two other described genera are close to *Furcitella*: *Öpikinella* Wilson and *Microtrypa* Wilson. The first of these genera is based on two brachial valves representing two species *Ö. affinis* Wilson and *Ö. salmoni* Wilson. This genus is characterized by its author as having an unusual septal system. "Three ridges lie between the brachiophores. The central ridge divides at a short distance from the beak, and the four continue for more than half the distance to the anterior margin, the central pair being longer than the lateral pair."

The writer has examined casts of these two specimens kindly provided by authorities of the Geological Survey of Canada. Examination indicates that the median ridge does not divide but that the 2 lateral ridges are implanted on the sides of the median ridge near its anterior extremity. This is precisely the condition that takes place in the septal arrangement of the high Middle and Upper Ordovician strophomenas. Accordingly the writer believes that *Öpikinella* is a synonym of *Strophomena* and has so placed it in this monograph.

The septal arrangement of *Microtrypa* is quite different from that of *Öpikinella* but is similar to that of *Furcitella*. The generic description of *Microtrypa* indicates that "*Microtrypa* is semicircular or subtriangular in outline; has a low evenly convex brachial and a resupinate pedicle valve, concave on the anterior part; a small round pedicle muscle scar and four septa in the brachial valve. The median septum is forked anteriorly and two laterals added, which do not curve as in *Trigrammaria*. The two limbs of the bifurcated median septum are subparallel, the two lateral septa are divergent. Thus the brachial interior arrives at the same septal system as *Öpikinella* of the *Rafinesquina* group, though the convexity of the valve is reversed."

Although the septal arrangements of *Microtrypa* and *Furcitella* are both characterized by a bifurcated median ridge their general contours and exterior are not the same. *Microtrypa* is like *Strophomena* in exterior details, but *Furcitella* is most like *Holtehdahlina* in ornamentation and profiles. Evidently the two genera are members of the same family.

FURCITELLA PLICATA Cooper, new species

Plate 229, D, figures 16-26

Of about usual size for the genus, wider than long; hinge about equal to or slightly greater than the midwidth; sides nearly straight; anterior margin broadly rounded; costellae subequal, numbering 4 to 5 in a millimeter at the anterior margin; many specimens marked anteriorly by strong radial wrinkles or plicae.

Pedicle valve gently convex in lateral profile with the front third to half flattened; umbo and median region marked by a low, narrow fold; flanks sloping to margins; posterolateral and marginal regions flattened. Interior with moderate-sized muscle area surrounded by a thin elevated rim; muscle area in length equal to one-quarter the valve length.

Brachial valve gently convex in lateral profile and with the maximum convexity located just anterior to the umbo; anterior profile broadly and gently convex; umbo flattened, marked at the beak by a single costella; sulcus shallow, obscure, disappearing near the middle; anteromedian region somewhat swollen to form a low fold; sides slightly convex. Interior with small and delicate cardinalia; adductor field with a prominent oblique ridge on each side of the median ridge.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|----------|-------------|-----------|
| Paratype (pedicle valve 117750a) .. | 10.7 | ? | 13.0 | 11.6 | ? |
| " (" " 117751c) .. | 8.9 | ? | 11.5 | 11.8 | ? |
| " (" " 117750c) .. | 10.5 | ? | 15.5 | 16.2 | ? |
| " (brachial valve 117751b) .. | ? | 9.2 | 10.9 | 11.0 | ? |
| " (" " 117751e) .. | ? | 10.9 | 15.7 | 14.6 | ? |

Types.—Holotype: 117750b; figured paratypes: 117750a,c, 117751a-c; unfigured paratypes: 117751d-g.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Discussion.—This is a rare species in the Oranda formation and is distinguished by the strong anterior radial plication. The species is similar to *F. scofieldi* (Winchell and Schuchert) but differs in being somewhat wider, in having somewhat finer ornamentation, more prominent development of the radial plication, and a smaller pedicle muscle area. *Furcitella scofieldi* has the radial plications seen in the Oranda species, but not one of the specimens in the National Collection has this feature as strongly developed as the Virginia specimens.

FURCITELLA SCOFIELDI (Winchell and Schuchert)

Plate 229, A, figures 1-5; plate 265, C, figures 5, 6

Strophomena scofieldi WINCHELL and SCHUCHERT, Amer. Geol., vol. 9, p. 286, Apr. 1, 1892; Geol. Minnesota, vol. 3, pt. 1, p. 398, pl. 31, figs. 18-21, 1895.

Streptorhynchus subsulcatum SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 335, pl. 4, fig. 39, Apr. 9, 1892.

This species has been well described by Winchell and Schuchert, but no mention was made of the tendency of some specimens to show obscure plication which undulates the anterior parts. Mention is made of the bifurcation of the median ridge which is one of the distinguishing characters of this shell.

Types.—Hypotypes: 117748, 117749a,b.

Horizon and locality.—Prosser formation (*Zygospira* and *Vellamo* [*Clitambonites*] beds) in Minnesota: At Cannon Falls, Goodhue County; Kenyon, Goodhue County; road cut 1.2 miles east of U. S. Highway 52, on south edge of Cannon Falls, Goodhue County; St. Paul; 11 miles southeast of Kasson, Dodge County; County Highway O, $\frac{1}{8}$ mile south of U. S. Highway 14, $1\frac{1}{2}$ miles east of Eyota, Olmsted County.

Genus MICROTRYPA Wilson, 1945

Microtrypa WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 144, 1945; Geol. Surv. Canada, Bull. 8, p. 111, 1946.

Microtrypa is characterized as "semicircular or subtriangular in outline; has a low evenly convex brachial and a resupinate pedicle valve, concave on the anterior part; a small round pedicle muscle scar and four septa in the brachial valve. The median septum is forked anteriorly and two laterals added, which do not curve as in *Trigrammaria*. The two limbs of the bifurcated median septum are subparallel, the two lateral septa are divergent. Thus the brachial interior arrives at the same septal system as *Öpikinella* of the *Rafinesquina* group, though the convexity of the valve is reversed. The [pseudo] punctae of the intermediate shell layer form a fine, unorganized network.

"*Microtrypa* differs from *Trigrammaria* in its low, even convexity, its general lack of a fold in the brachial valve, and in having 4 subparallel septa in the brachial valve instead of 3."

Microtrypa resembles *Furcitella* in some details, especially in the forking of the median ridge. *Furcitella*, however, is not as markedly resupinate as *Microtrypa*, indeed it is generally biconvex in profile but with the brachial umbo flattened or slightly concave.

MICROTRYPA ALTILIS Wilson

Microtrypa altilis WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 144, pl. 2, figs. 10-12, 1945; Geol. Surv. Canada, Bull. 8, p. 111, pl. 10, figs. 10-12, 1946.

Type.—Holotype G.S.C. 7649.

Horizon and locality.—Leray-Chaumont formation, Stewart Quarry, Rockland, Ontario.

MICROTRYPA ? NASUTA Wilson

Microtrypa ? nasuta WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 146, pl. 2, figs. 13, 14, 1945; Geol. Surv. Canada, Bull. 8, p. 112, pl. 10, figs. 13, 14, 1946.

Types.—Holotype: G.S.C. 7641; paratype: G.S.C. 7641a.

Horizon and locality.—Rockland formation, Angegardien road, 4 miles west of L' Orignal, Ontario.

Genus HOLTEDAHLINA Foerste, 1924

Plate 229, B, figures 6-8

Figures of the interior and exterior of this genus are introduced for comparison with *Furcitella* which has been confused with *Holtedahlina*.

Types.—Figured specimens: 117744, 117747a,b.

PLATYMENA Cooper, new genus

(Greek *platys*, flat; *mene*, crescent)

Shells attaining a width of about $\frac{3}{4}$ inch; subrectangular in outline; planoconvex to slightly concavo-convex; hinge as wide or wider than the midwidth. Surface multicostellate, costellae unequal in size, a larger one setting off one to several finer ones. Pseudopunctae finely matted.

Pedicle valve with stout teeth, no dental plates, but a thickened rim extends anteriorly from the dental ridge and nearly encloses the small muscle field; diductor scars subflabellate; adductor scars small, associated with a thickened ridge on the inner sides of the diductors; median ridge, low, short, not extending anterior to the anterior ends of the diductors. Valve thickened inside the margin. Pseudodeltidium small; chilidium small.

Brachial interior with delicate bilobed cardinal process; notothyrial platform moderately thick, prominent; brachiophores long, slender blades enclosed by delicate cups to form broad sockets; median ridge short; adductors separated by 2 oblique, low ridges on each side of the median ridge. Visceral region surrounded by a thickened margin.

Genotype.—*Platymena plana* Cooper, new species.

Discussion.—*Platymena* is characterized by its planoconvex profile, the small muscle area enclosed by strong ridges, a minute bilobed cardinal process, and obscure median ridge. It differs from *Macrocoelia* and *Öpikina* in the profiles of the valves and the delicacy of the cardinalia. It also differs in the possession of a broad and thickened border around the visceral region of both valves.

PLATYMENA ? BELLATULA Cooper, new species

Plate 230, B, figures 11-13

Shell of medium size, attaining a width of about $\frac{3}{4}$ inch; subrectangular in outline, with the length slightly less than the width; sides gently oblique; anterior margin broadly rounded; hinge forming the greatest width; cardinal extremities acute; surface marked by costellae unequal in size, about 3 or 4 to the millimeter at the front margin.

Pedicle valve with lateral profile gently but unevenly convex, the most convex part located in the posterior third; anterior profile evenly and gently convex. Umbo narrowly convex and with short, steep umbonal slopes to the posterolateral areas, median region gently swollen; anterior slope long and gentle; lateral slopes gentle. Interarea moderately long, apsacline; foramen small.

Brachial valve very gently concave to flat in both profiles; umbo concave; posterolateral areas gently and narrowly concave; rest of valve nearly flat.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|----------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 16.1 | 15.7 | 19.6 | 20.5 | 2.8 | 2.8 |
| Paratype | 17.6 | 16.4 | 21.4 | 21.5+ | 2.6 | 2.9 |

Types.—Holotype: 117758; unfigured paratype: 117757.

Horizon and locality.—Bromide formation (Pooleville member) in Oklahoma: On Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County; 162 feet below the massive limestone, second dam on Spring Creek, northwest of Woodford, Murray County.

Discussion.—The interior of this species is unknown; consequently it is placed in *Platymena* with a query. The species is about the same size as *P. plana* but the sides are more oblique, the shell thickness is greater, and the interarea is longer and has a prominent pseudodeltidium.

PLATYMENA PLANA Cooper, new species

Plate 230, A, figures 1-10; plate 266, D, figures 10-16

Shell small, planoconvex in lateral profile; slightly wider than long. Hinge forming the widest part; cardinal extremities slightly alate. Lateral margins nearly straight to slightly oblique. Anterior margin narrowly rounded. Ornamentation consisting of costellae of unequal size, the larger ones separated by 1 or 2 fine costellae and all crossed by fine threadlike concentric lines. At the front margin of a brachial valve 10 mm. in length 3 of the larger costellae occupy a space of 1 mm.

Pedicle valve very slightly convex in lateral profile with the most convexity in the posterior third and the front somewhat flattened. Umbo narrowly convex and produced forward for about one-third the length as a low, narrow fold. Front half and anterolateral portions flattened. Slopes from umbo to cardinal extremities gentle. Interarea moderately long; pseudodeltidium short.

Brachial valve characterized by a narrow, fairly deep sulcus originating at

the beak and extending for about one-quarter the length where it is lost in the flat shell; remainder of valve nearly flat or very slightly concave. Interarea short.

Interior of pedicle valve with short and shallow delthyrial cavity, short, thick teeth, short muscle field surrounded on each side by moderately strongly elevated thickenings. Diductor impressions separated by a low double ridge bearing the adductor impressions. Anterior and lateral third of shell strongly thickened and bounding a shallow visceral area.

Brachial valve interior with slender brachiophores and delicate cardinal process. Median ridge short, wide and low; brachiophores supported by considerable thickening. Cardinal process consisting of two slender ridges.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Paratype (117759a)..... | 14.8 | 13.7 | 18.0 | 19.1 | 2.0 ? |
| " (117760c)..... | 14.5 | 13.9 | 17.9 | ? | 1.4 |

Types.—Holotype: 117759b; figured paratypes: 117759a,c-e, 117760a-d.

Horizon and locality.—Middle and upper Arline formation in Tennessee: Glade $\frac{1}{4}$ mile southeast of Friendsville; 100 yards southwest of Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; 5 miles southeast of Knoxville; and 1,500 feet south of the mouth of Burnett Creek, Shooks Gap (T.V.A. 147-NE) Quadrangle; McMullens, Meadow (T.V.A. 139-NW) Quadrangle.

Discussion.—This species is compared with *P. ? bellatula* under the discussion of that species. No other species of the genus is now known. *Platymena* is common in the Arline formation in the Friendsville area. It occurs also in nodular limestones of the contemporaneous Athens formation.

GLYPTOMENA Cooper, new genus

(Greek *glyptos*, engraved; *mene*, crescent)

Shells generally subrectangular in outline, wider than long and attaining a width of an inch or more. Concavo-convex in profile; surface beautifully costellate, larger costellae setting off groups of numerous finer costellae; whole surface crossed by fine fila. Pseudopunctae forming a dense mat.

Pedicle valve with small, narrowly convex pseudodeltidium; foramen present, minute. Interior with short, oblique dental plates with narrow umbonal cavities. Muscle field small, subcircular in outline and with the anterior ends of the diductors separated by a low ridge.

Brachial interior with narrow-lobed, short-shafted, bilobed cardinal process mounting a low notothyrial platform; brachiophores long, thin, flat, obliquely placed blades supported by swelling of notothyrial platform; median ridge short and low; adductor scars small; adductor and accessory septa appearing as remnants only, usually absent. Subperipheral rim, low, not greatly thickened, usually somewhat beaded.

Genotype.—*Glyptomena sculpturata* Cooper, new species.

Discussion.—This genus suggests *Macrocoelia*, *Platymena*, or *Öpikina*. The nature of the pseudopunctae is like that of each of these genera, but exterior and interior details will serve to distinguish them.

Glyptomena differs from *Macrocoelia* externally in the presence of a well-marked foramen, the well-developed pseudodeltidium, and the zonated character of the ornamentation. Inside the pedicle valve the muscle field is small and the diductors are marked by a single median ridge only; in the brachial valve *Glyptomena* has a modest development of the median ridge and scarcely any trace of the 5 accessory septa which mark *Macrocoelia*.

Platymena is like *Glyptomena* inside the brachial valve, but the flat brachial valve makes an easy mark of distinction. This flatness of the brachial valve leads to other internal differences. The visceral region of *Platymena* is depressed below the somewhat thickened marginal region.

Öpikina can be readily distinguished from *Glyptomena* externally because it is usually more or less strongly geniculated and its ornamentation is not so beautifully zoned as that of *Glyptomena*. These distinctions do not hold in all cases because some species of *Öpikina* are not very noticeably geniculated and a few have fairly well zoned costellae, particularly in the young stages. In spite of these difficulties, the interior of the brachial valve of *Öpikina*, in all known species, has the septa strongly developed. In some instances the anterior septa are buried, particularly the median one, but the lateral septa and adductor ridges are usually well marked.

GLYPTOMENA ? BELLA Cooper, new species

Plate 246, A, figures 1, 2

Shell fairly large, attaining a width of over an inch; subrectangular, wider than long; sides gently rounded, subparallel; hinge equal to or narrower than the midwidth; anterior margin broadly rounded; costellae well differentiated but zonation narrow, 3 or 4 of the fine costellae separating the larger ones.

Pedicle valve gently and evenly convex in lateral profile; maximum convexity near the middle; anterior profile broadly convex, the median region somewhat narrowly humped; umbo narrowly convex to form a low fold that extends more or less distinctly nearly to the anterior margin; median region gently swollen; lateral slopes long and gentle; anterior slope long and gentle.

Brachial valve moderately concave in lateral profile and with the maximum concavity at about the middle; umbo sulcate, the sulcus extended anteriorly beyond the middle; sides and anterior margin gently curved toward the brachial valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 18.7 | ? | 24.8 | 23.4 | ? | 2.8 |
| Paratype (117852b) .. | ? | 21.3 | 29.1 ? | 31.0 ? | ? | ? |
| “ (117852c) .. | 20.0 | ? | 25.3 | 25.2 | ? | 2.6 |

Types.—Holotype: 117852a; figured paratype: 117852b; unfigured paratypes: 117852c,d.

Horizon and locality.—Murat formation in Virginia: Along the road and ridge 2 miles northwest of Lexington, vicinity of Whistle Creek, Lexington (15') Quadrangle.

Discussion.—Although the interior of this species is not known, it is assigned to *Glyptomena* because its ornamentation is so much like that of *Glyptomena*. This is a large species, the largest so far assigned to the genus. It is therefore quite different from *G. parvula* and *G. sculpturata* which are much smaller. *Glyptomena prisca* is a moderately large species, but its shape is totally different from that of *G. bella*.

GLYPTOMENA ? DISTANS (Raymond)

Plate 231, B, figure 8

Rafinesquina distans RAYMOND, Ann. Carnegie Mus., vol. 3, p. 575, 1906; idem, vol. 7, No. 2, p. 234, pl. 35, fig. 1, 1911.

The ornamentation of this species suggests that of *Glyptomena* rather than *Rafinesquina*.

Type.—Holotype: Carnegie Mus. 5452.

Horizon and locality.—Crown Point formation in New York: At Crown Point, Port Henry (15') Quadrangle.

Valcour formation, in New York: On Valcour Island, Plattsburg (15') Quadrangle.

GLYPTOMENA ? MINGANENSIS (Twenhofel and Stiles)

Strophomena alternata BILLINGS (not Conrad), Canadian Nat. Geol., vol. 4, p. 443, 1859.

Rafinesquina champlainensis minganensis Twenhofel and Stiles in TWENHOFEL, Geol. Soc. Amer. Special Pap. 11, p. 50, pl. 8, figs. 3-6, 1938.

This species is doubtfully assigned to this genus on the basis of its ornamentation. Possibly it is the young of a *Macrocoelia*, but this cannot be settled until interiors have been found or made.

Horizon and locality.—Mingan formation (lower 50 to 60 feet): In the Mingan Islands, St. Lawrence River.

GLYPTOMENA PARVULA Cooper, new species

Plate 245, A, figures 1-8

Shell small for the genus, wider than long and with the hinge forming the widest part; sides nearly straight; anterior margin broadly rounded; surface costellate, the stronger costellae conspicuous in a mat of finer ones, the latter forming broad zones between the strong costellae.

Pedicle valve strongly and evenly convex in lateral profile and with the maximum convexity located at the middle; anterior profile strongly domed; umbonal region strongly swollen; median region inflated; lateral and anterior slopes long and steep. Interarea fairly long. Interior with stout, nearly vertical dental plates; muscle field with floor somewhat thickened and in length equal to about one-third the total shell length.

Brachial valve gently concave in the posterior half, deepest just anterior to the middle and with the anterior margin moderately strongly bent toward the brachial valve; sides more gently deflected in the direction of the brachial valve than the front margin. Interior with cardinalia somewhat thickened; adductor field triangular, thickened, with apex directed anteriorly; adductors separated by a low median ridge.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thick-ness | Height |
|----------|--------------|--------|-----------------|----------|-------------|------------|--------|
| Paratype | (117855b) .. | ? | 10.8 | 13.1 | 13.5 | ? | ? |
| " | (117855g) .. | 12.0 | ? | 13.2 | 12.5 | ? | 4.9 |

Types.—Holotype: 117855e; figured paratypes: 117855f-h; unfigured paratypes: 117855a-d.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At the Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—As its name implies this is a species of small size characterized by deep concavity and squarish outline. It is most like *G. sculpturata* but is smaller, more deeply concave, and with a more strongly convex pedicle valve.

GLYPTOMENA ? PRISCA (Raymond)

Plate 235, A, figure 1; plate 235, D, figures 3, 4

Strophomena prisca RAYMOND, Amer. Journ. Sci., ser. 4, vol. 20, p. 369, 1905; Ann. Carnegie Mus., vol. 7, No. 2, p. 234, pl. 35, figs. 2, 3, 1911.

The types of this little species are poorly preserved but they show clearly that the species must have had a concavo-convex shell quite unlike that of *Strophomena*. The interior of this species is not known, and the specimens in the National Museum show none of these essential details.

The pedicle valve assigned to this species has low convexity but with the median region somewhat narrowly swollen. The lateral slopes are long and gentle. The costellae of this valve appear somewhat more crowded than those of the brachial valve and number 3 or 4 of the stronger ones at the front margin.

The brachial valve has a well-defined sulcus beginning at the umbo and definable nearly to the anterior margin. The costellae of this valve are more definitely zoned with 2 of the stronger costellae in 1 mm.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thick-ness | Height |
|----------|--------------|--------|-----------------|----------|-------------|------------|--------|
| Hypotype | (117854a) .. | ? | 10.6 | 14.0 | 12.4 | ? | ? |
| " | (117853) ... | 13.9 | ? | 15.8 | 15.3 | ? | 1.9 |

Types.—Holotype: Carnegie Mus. 5464; figured hypotypes: 117853, 117854a.

Horizon and locality.—Crown Point formation in New York: On Valcour Island, Plattsburg (15') Quadrangle.

Same formation in Vermont: On Fort Cassin and Appleton Point near Fort Cassin, Port Henry (15') Quadrangle.

Discussion.—The interior details of this species are unknown; consequently, it is necessary to question the generic assignment which was made on the basis of form and ornamentation. This species is somewhat suggestive of *G. sculpturata* but has a different outline, being squarer and more deeply concave.

GLYPTOMENA SCULPTURATA Cooper, new species

Plate 246, F, figures 16-23

Shell attaining a width of about $\frac{3}{4}$ inch; wider than long and with the hinge forming the widest part; sides gently rounded, oblique to subparallel; cardinal extremities slightly acute, anterior margin broadly rounded. Strong costellae separated by groups of smaller costellae numbering as high as 7.

Pedicle valve unevenly convex in lateral profile, the posterior two-thirds gently convex, the anterior third fairly strongly bent toward the brachial valve; anterior profile moderately and broadly convex; umbonal region gently swollen; median region gently swollen; anterior and lateral slopes short and moderately steep. Interarea short.

Brachial valve gently concave in lateral profile with the greatest concavity located anterior to the middle; umbo concave, the concavity produced anteriorly to form a shallow sulcus; sides and anterior margin fairly strongly bent toward the brachial valve.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|----------|----------------|--------|--------------------|----------|----------------|-----------|--------|
| Paratype | (117856e)..... | 14.3 | 13.1 | 17.2 | 19.2 | 1.9 | 3.7 |
| " | (117856b)..... | 14.3 | 12.0 | 13.9 | 14.7 | ? | ? |

Types.—Holotype: 117856c; figured paratypes: 117856a,b,d; unfigured paratypes: 117856e,f.

Horizon and locality.—Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—This species is characterized by moderate convexity and concavity and obliquely sloping sides. It is a larger, less concave, and less convex species than *G. parvula*. Its convexity is greater than that of *G. ? prisca*, and its shape is somewhat more rectangular and with more sloping sides than the Chazy species from New York.

GLYPTOMENA sp. 1

Plate 235, B, figure 2

This species is suggestive of *G. ? prisca* (Raymond) but is more convex and does not have as narrowly convex an umbonal region on the pedicle valve.

Measurements in mm.—117857a, length 12.9, midwidth 13.9, hinge width 13.6, height 2.0.

Figured specimen.—117857a.

Horizon and locality.—Ward Cove ? formation in Virginia: $\frac{1}{2}$ mile south of Rocky Gap, Pocahontas (30') Quadrangle.

Genus **RAFINESQUINA** Hall and Clarke, 1892

Rafinesquina HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 281, 1892.—SALMON, Journ. Paleont., vol. 16, No. 5, p. 570, 1942.

RAFINESQUINA LENNOXENSIS Salmon

Rafinesquina lennoxensis SALMON, Journ. Paleont., vol. 16, No. 5, p. 576, pl. 85, figs. 18-20, 1942.—WILSON, Geol. Surv. Canada, Bull. 8, p. 70, text fig. 1, No. 4; pl. 5, fig. 5, 1946.

Types.—Holotype: Columbia Univ. 25884; paratype: Columbia Univ. 25885.

Horizon and locality.—Rockland formation (Napanee member) in Ontario, Canada: On Selby Creek, near Napanee, Lennox and Addington County.

Same formation and member in New York: On the Sugar River south of Port Leyden, Port Leyden (15') Quadrangle.

RAFINESQUINA OLLIFORMIS Salmon

Rafinesquina olliformis SALMON, Journ. Paleont., vol. 16, No. 5, p. 577, pl. 85, figs. 21, 22, 1942.

Type.—Holotype: Columbia Univ. 25886.

Horizon and locality.—Rockland formation (Napanee member) in Ontario, Canada: On the Selby Road 1 mile from Napanee, Lennox and Addington County.

RAFINESQUINA PLANULATA Cooper, new species

Plate 266, A, figures 1-4

Of about medium size for the genus, wider than long; hinge equal to or slightly greater than the midwidth; sides nearly straight or slightly oblique; anterior margin broadly rounded; cardinal extremities nearly a right angle or slightly acute. Pedicle valve marked by a median costella stronger than the others; median region from beak to margin marked by several costellae almost as strong as the median one; lateral areas marked by costellae of varying sizes, 1 to 4 of the finer ones alternating with the stronger costellae.

Pedicle valve almost flat in lateral and anterior profile; beak prominent and umbo slightly and narrowly swollen. Interior with moderately long, slender dental ridges diverging at an angle of about 90°; muscle area small, heart shaped.

Brachial valve very gently concave in lateral profile and with the maximum concavity located near or posterior to the middle; anterior third deflected slightly toward the brachial valve but nearly flat; cardinalia delicate; median ridge and notothyrial platform slightly thickened; cardinal process small and delicate.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 11.8 | ? | 16.7 | 18.8 | ? |
| Paratype (" " 123281g) .. | 16.5 | ? | 21.4 | 24.0 | ? |
| " (brachial valve 123281k) . | ? | 12.3 | 17.0 | ? | ? |
| " (" " 123281-l) . | ? | 12.6 | 16.9 | 19.9 | ? |

Types.—Holotype: 123281a; figured paratypes: 123281e,f,j; unfigured paratypes: 123281b-d,g-i,k-m.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle.

Discussion.—This is a very small and delicate species and is the only representative of the genus so far found in the Oranda formation. It is characterized by its small size and the delicate character of its cardinalia. It differs from *R. trentonensis* in its smaller size, planoconvex profile, and delicate cardinalia.

RAFINESQUINA PRESTONENSIS Salmon

Rafinesquina prestonensis SALMON, Journ. Paleont., vol. 16, No. 5, p. 578, pl. 85, figs. 28-33, 1942.—WILSON, Geol. Surv. Canada, Bull. 8, p. 75, text fig. 4, No. 5; pl. 7, figs. 4a-c, 1946.

Type.—Holotype: Columbia Univ. 25888.

Horizon and locality.—Rockland formation and Guttenberg member of the Decorah formation in Illinois: At Milbrig.

RAFINESQUINA SINCLAIRI Salmon

Plate 266, B, figures 5-7; plate 266, C, figures 8, 9

Rafinesquina elongata SALMON (not Teichert, 1937), Journ. Paleont., vol. 16, No. 5, p. 576, pl. 85, figs. 14-17, 1942.

R. sinclairi SALMON, idem, vol. 17, No. 3, p. 309, 1943.

This name is used for specimens occurring in the Guttenberg member in Wisconsin, the probable Guttenberg in Missouri, and the Auburn chert in Missouri. The specimens indicate a species variable in length-width relationship and in convexity. Both of these features apparently depend on age. The name *sinclairi* is used in preference to *R. alternata*, to which this shell is related, because the ornamentation and cardinal extremities are more like that of the Guttenberg species. *Rafinesquina sinclairi* appears to be somewhat more convex than *R. alternata*, and the ornamentation is featured by a preponderance of closely spaced strong costellae separated by 1 to 4 of the fine costellae.

Figured hypotypes.—117858a,b, 117859.

Horizon and locality.—Auburn chert in Missouri: $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle.

Barnhart formation in Missouri: On U. S. Highway 61, 0.1 mile south of Salt River, north of New London, Ralls County; on U. S. Highway 61, 0.2 mile south of Koch School, NE. corner SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T. 41 N., R. 6 E., 2 miles south of Barnhart, Kimmswick (15') Quadrangle.

Guttenberg member in Wisconsin: Above the 8 inches of blue clay of the Platteville, on Wisconsin Highway 151, 0.7 mile northeast of Dickeyville, Grant County; NW $\frac{1}{4}$ sec. 19, T. 3 N., R. 1 W. Grant County; 2 miles west of Platteville; 0.1 mile south of the Little Platte River on Wisconsin Highway 81, 2 miles northwest of Platteville, Mineral Point (30') Quadrangle.

RAFINESQUINA TRENTONENSIS (Conrad)

Plate 247, B, figures 5, 6; plate 266, E, figure 17

Rafinesquina trentonensis (Conrad) SALMON, Journ. Paleont., vol. 16, No. 5, p. 574, pl. 85, figs. 1-10, 1942 (for complete synonymy).

The name *R. trentonensis* has now superseded the old and familiar *Rafinesquina alternata*. The latter had become almost a fixture in our Ordovician faunal lists, but many other familiar names have fallen to nomenclatorial technicalities. The details are explained by Dr. Eleanor Salmon in her detailed study of the Mohawkian Rafinesquinae.

Dr. Salmon included *R. hermitagensis* Bassler under the synonymy of *R. trentonensis*, but this seems to be an error. That species appears to differ in shape and ornamentation from *R. trentonensis*, and to have a less well developed interior. The Hermitage species was taken in sandstone and is preserved as impressions on the rock. Nevertheless, all the details of the interior and exterior are clearly visible and seem quite distinct from the Trenton species.

Rafinesquina trentonensis is identified in the Guttenberg of Illinois by Dr. Salmon and in the Guttenberg of Wisconsin by other authors. The specimens in the National Museum and ones collected by the writer in Wisconsin and Missouri seem to belong to *R. sinclairi* rather than *R. trentonensis*, but some specimens were close to the latter species. More extensive collections may in the future show the presence of this species in Wisconsin.

In the Appalachians *Rafinesquina* is not well represented in the rocks covered by this monograph. It is however found in abundance in the Collierstown formation, but the specimens available are too poor for accurate identification. They are tentatively placed under the above heading.

Figured specimens.—97578a,b, 123282.

RAFINESQUINA in Canada

In 1946 Dr. Alice E. Wilson described many species of *Rafinesquina* from the Leray-Rockland interval in the Ottawa-St. Lawrence Lowland. None of these species has been identified in any of the National Museum collections, but they are listed here because they must be checked in any future work on *Rafinesquina* in eastern United States. The first set of figures after the name refers to the pages and plates in the original description of most of these species in the Transactions of the Royal Society of Canada, ser. 3, vol. 38, sec. 4, 1944; the second set of figures refers to Geological Survey of Canada, Bulletin 8, 1946.

Rafinesquina alternata (Conrad) Wilson, 1946, p. 66, text fig. 1, No. 3; pl. 5, fig. 4.

R. alternata alata Wilson, 1944, p. 160, text fig. 2, No. 4; pl. 1, fig. 17;

1946, p. 66, text fig. 2, No. 4; pl. 5, fig. 18.

R. alternata intermedia Wilson, 1944, p. 161, text fig. 1, No. 1; pl. 1, fig. 1;

1946, p. 67, text fig. 1, No. 1; pl. 5, fig. 3.

R. alternata plana Wilson, 1944, p. 161, text fig. 1, No. 1; pl. 1, fig. 1.

1946, p. 67, text fig. 1, No. 1; pl. 5, figs. 1, 2.

This species is stated to have been taken from the Lowville formation as well as from the Leray-Rockland beds.

- R. alternata platys* Wilson, 1944, p. 162, text fig. 2, No. 1; pl. 1, fig. 10.
1946, p. 68, text fig. 2, No. 1; pl. 5, fig. 11.
- R. alternata semiquadrata* Wilson, 1944, p. 164, text fig. 2, No. 3; pl. 1, fig. 6.
1946, p. 69, text fig. 2, No. 3; pl. 5, fig. 7.
- R. alternata transversa* Wilson, 1944, p. 165, text fig. 1, No. 6; pl. 1, fig. 11.
1946, p. 69, text fig. 1, No. 6; pl. 5, fig. 12.
- R. esmondensis borealis* Wilson, 1944, p. 169, text fig. 4, No. 1; pl. 1, fig. 8.
1946, p. 72, text fig. 4, No. 1; pl. 5, fig. 9.
- R. hullensis* Wilson, 1944, p. 170, text fig. 4, No. 6; pl. 1, fig. 19.
1946, p. 73, text fig. 4, No. 6; pl. 5, fig. 20.
- R. opeongoensis* Wilson, 1944, p. 171, text fig. 5, No. 5; pl. 1, fig. 16.
1946, p. 73, text fig. 5, No. 5; pl. 5, fig. 17.
- R. orleansensis* Wilson, 1944, p. 171, text fig. 5, No. 6; pl. 1, fig. 13.
1946, p. 74, text fig. 5, No. 6; pl. 5, fig. 14.
- R. rotunda* Wilson, 1944, p. 174, text fig. 5, No. 4; pl. 1, fig. 7.
1946, p. 75, text fig. 5, No. 4; pl. 5, fig. 8.
- R. subtrigonalis* Wilson, 1944, p. 175, text fig. 4, No. 4; pl. 1, fig. 15.
1946, p. 76, text fig. 4, No. 4; pl. 5, fig. 16.
- R. miodeltoidea* Wilson, 1944, p. 179, text fig. 8, No. 2; pl. 2, fig. 9.
1946, p. 79, text fig. 8, No. 2; pl. 6, fig. 9.
- R. okulitchi* Wilson, 1944, p. 181, text fig. 7, No. 2; pl. 2, fig. 7.
1946, p. 80, text fig. 7, No. 2; pl. 6, fig. 7.
- R. praedeltoidea* Wilson, 1944, p. 183, text fig. 8, No. 3; pl. 2, fig. 11.
1946, p. 81, text fig. 8, No. 3; pl. 6, fig. 11.
- R. semicircularis minor* Wilson, 1944, p. 186, text fig. 6, No. 1; pl. 2, fig. 3.
1946, p. 83, text fig. 6, No. 1; pl. 6, fig. 3.

COLAPTOMENA Cooper, new genus

(Greek *colapto*, chisel; *mene*, crescent)

Shells large, attaining a length and width of nearly 2 inches; planoconvex to perceptibly concavo-convex; valves strongly compressed and strongly suggesting *Leptostrophia* in profile and general form. Surface costellate, costellae alternating strong and fine; concentric fila strong; posterior margins marked by strong, oblique wrinkles. Pseudopunctate, the pseudopunctae closely matted and fine.

Interior of pedicle valve with pseudodeltidium obsolete; muscle area large, subcircular; diductor scars subflabellate; adductor field located in the posterior of the muscle field, marked by 2 low ridges separated by a narrow groove; pallial marks prominent; vascula media splitting at the anteromedian end of the diductor scar, splitting into 3 trunks, 1 extending directly toward the anterior, the second anterolaterally, and a third directed posterolaterally.

Brachial interior with narrow, subcarinate chilidium; cardinal process large and stout; adductor scars located on each side of a short, rounded median ridge, the outer scars being the larger.

Genotype.—*Colaptomena leptostrophoidea* Cooper, new species.

Discussion.—This genus is most like *Rafinesquina* and is probably a lateral divergence from that genus. It differs from *Rafinesquina* in the pedicle valve not being marked by the single enlarged and elevated median rib so common in the

Trenton rafinesquinoids. On the inside of the pedicle valve the muscle field is large and broadly flabellate, and the pallial marks are deeply impressed.

Inside the brachial valve interesting differences appear between *Colaptomena* and *Rafinesquina* sensu stricto. The cardinal process of *Colaptomena* is large and erect whereas that of *Rafinesquina* is of moderate size. In *Colaptomena* the adductor field is somewhat diamond shaped and moderately deeply impressed. No adductor ridges appear, but the field is bisected by a moderately long, low, rounded median ridge that extends posteriorly to the platform bearing the cardinal process. Another important feature of the genus is the reduction of the pseudodeltidium to disappearance. The pseudopunctae are coarse and densely matted together as in *Öpikina* rather than distantly arranged in rows as in *Rafinesquina*.

COLAPTOMENA LEPTOSTROPHOIDEA Cooper, new species

Plate 267, A, figures 1-10

Shell large, subquadrate to subrectangular in outline; slightly wider than long; hinge variable, wider than the midwidth in the young, narrower than midwidth in old adults; cardinal extremities slightly alate and pointed to rounded obtuse; sides subparallel; anterior margin somewhat narrowly rounded. Pedicle valve more strongly costellate than the brachial valve, 2 large and 2 small costellae at the front margin; brachial valve with 5 costellae in 1 mm.

Pedicle valve perceptibly convex in lateral profile and with the umbonal region the most convex part; anterior profile broadly and gently convex. Umbonal region gently swollen, the swelling continuing noticeably to about the middle; remainder of valve nearly flat. Interarea short, only slightly longer than the brachial one.

Brachial valve with umbo concave and posterior median region gently concave, rest of valve gently concave or nearly flat.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 42.0 | 41.1 | 40.0 | ? | 3.8 | 5.7 ? |
| Paratype (117763a)..... | 37.7 | ? | 39.3 | 38.5 | ? | 3.0 ? |
| " (117763e)..... | 36.2 | ? | 41.3 | 35.8 | ? | 3.0 ? |
| " (117763d)..... | 19.3 | ? | 20.5 | 20.6 | ? | 1.3 |

Types.—Holotype: 117761; figured paratypes: 117762a,c, 117763a,b,e; unfigured paratypes: 117762b, 117763c,d.

Horizon and locality.—Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: County Road 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—No other species like this one is now known.

MACROCOELIA Cooper, new genus

(Greek *macro*, large; *koilos*, hollow)

Shells large, attaining a width of more than 2 inches; subrectangular in outline, usually wider than long; hinge variable; nearly planoconvex to strongly

concavo-convex; surface multicostellate, costellae unequal in size and crossed by strong concentric fila. Pseudopunctae forming a dense mat.

Interior of pedicle valve with wide and shallow delthyrial cavity; dental plates rudimentary to obsolete; muscle field large, subcircular, not surrounded by a thickened ridge; diductors flabellate; adductors small, associated with 2 ridges along the inner edges of the diductor scars; median ridge poorly developed. Pseudodeltidium short; chilidium fully developed. Inner margin usually with thickened rim.

Interior of brachial valve with moderately thickened notothyrial platform; brachiophores short, flat blades partially buried in the adventitious shell material of the socket and notothyrial platform. Median ridge short and low; adductor field marked by an oblique, low ridge; 2 lateral ridges and 1 median ridge appear anterior to the broad median ridge attached to the notothyrial platform. Inside the margin marked by a subperipheral thickening.

Genotype.—*Macrocoelia obesa* Cooper, new species.

Discussion.—This is a genus including species of large-sized shells, mostly with broadly convex profiles and without marked geniculation. Distinction between this genus and some forms of *Öpikina* is difficult. The shell structure of *Macrocoelia* is densely pseudopunctate like that of *Öpikina* and thus quite different from *Rafinesquina* to which many of these shells were hitherto referred.

In the pedicle valve the delthyrium of *Macrocoelia* may be unmodified by a pseudodeltidium or only partially covered by a remnant of a pseudodeltidium. In *Öpikina* on the other hand the pseudodeltidium is usually well developed. The musculature of the two genera is very similar, but that of *Macrocoelia* may be somewhat larger. A difference exists between the two genera in the peripheral rim, that of *Macrocoelia* being farther toward the anterior than in *Öpikina*. This is undoubtedly a manifestation of the lack of geniculation in *Macrocoelia*.

The brachial valves of *Macrocoelia* and *Öpikina* are similar in plan but different in detail. The adductor ridges are 4 in number in both genera, but those of *Macrocoelia* are not strong and in most of the species are poorly developed, if at all. The median ridge of *Macrocoelia* is strong, in *Öpikina* it is weak and in old shells generally covered up.

As here identified *Macrocoelia* ranges from the Crown Point formation of the Chazyan group to the Benbolt formation. It is not an abundant fossil in any of the formations of the Appalachians or elsewhere.

MACROCOELIA BELLA Cooper, new species

Plate 234, B, figures 6-13

Large, wider than long, with the hinge slightly narrower than the width at the middle; sides gently rounded, subparallel to sloping gently inward; cardinal extremities nearly a right angle; surface costellate, costellae variable. Ornamentation in posterior and median portions of brachial valve consisting of low costellae of 2 sizes, the larger ones separated by 1 to 8 smaller ones and the costellae becoming more even in size anteriorly, numbering 4 to the millimeter at the front margin. Costellae of pedicle valve less strongly differentiated and the

larger ones separated by only 1 or 2 of the finer ones and numbering 2 or 3 to the millimeter at the front margin. Entire surface covered by fine fila which cancellate the finer costellae in the posterior and median parts, especially those of the brachial valve.

Pedicle valve somewhat variable in lateral profile, usually fairly evenly and moderately convex and with the maximum convexity at the middle; anterior profile moderately domed. Beak small and inconspicuous; umbonal region gently swollen; median region fairly strongly swollen with anterior and lateral slopes moderately steep. Pseudodeltidium short; interarea short.

Brachial valve moderately concave in lateral profile, the maximum concavity somewhat anterior to the middle; umbo concave; median region gently concave to nearly flat; sides and anterior third deflected gently to moderately in the direction of the brachial valve. Chilidium large and convex. Interior with long-shafted, erect cardinal process lobes, slightly thickened notothyrial platform, shallow sockets, and subdued adductor ridges.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|----------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 38.4 | 36.4 | 44.7 | 42.5 | 8.4 |
| Paratype (117764)... | 39.6 | 36.9 | 48.0 | ? | 6.3 |

Types.—Holotype: 117766a; figured paratypes: 117764, 117765; unfigured paratypes: 117766b.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: From the top of the green shale on the east side of the cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; 4 miles south of Davis, Murray County; *Valcourea* zone on Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County; *Sowerbyites* bed, same as preceding; west Spring Creek, east of Pooleville, Murray County; west of Nebo store, sec. 22, T. 2 S., R. 3 E., Murray County; middle of the east line of sec. 33, T. 2 S., R. 2 E., 2 miles northeast of Springer, Carter County; $\frac{1}{4}$ mile west of U. S. Highway 77, sec. 25, T. 2 S., R. 1 E., Carter County.

Discussion.—This species is characterized by large size, strong convexity, particularly in the anterior half, and moderately strong ornamentation. Of described species it is most like *M. obesa* of the Arline formation of Tennessee. It differs however in the lateral profile of the pedicle valve which is more evenly convex in the Tennessee species, in a less concave brachial valve and somewhat stronger ornamentation. The profile of *M. bella* is also less regular than that of *M. champlainensis*.

MACROCOELIA CHAMPLAINENSIS (Raymond)

Rafinesquina champlainensis RAYMOND, Bull. Amer. Paleont., vol. 3, p. 37, pl. 18, figs. 5, 6, 1902; Ann. Carnegie Mus., vol. 7, No. 2, p. 233, figs. 6-9, 1911.

Horizon and locality.—Crown Point formation in New York: At Crown Point, Chazy, Valcour Island, Plattsburg (15') Quadrangle.

Same formation in Vermont: On Isle la Motte, Plattsburg (15') Quadrangle; South Hero, Rouses Point (15') Quadrangle.

MACROCOELIA DUPLISTRIATA (Willard)

Plate 173, F, figure 31; plate 236, B, figures 8-12; plate 249, B, figures 10-12

Rafinesquina duplistriata WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 281, 1928.

Willard designated two specimens as cotypes. One of these is a pedicle valve showing the exterior and preserving the profile. The other is an interior of a brachial valve showing the subperipheral thickening and the 5 ridges associated with the adductor field. Inasmuch as the specific characters chiefly appear on the exterior of these shells, pedicle valve M.C.Z. 8621 is chosen as lectotype for the species.

Evidence in the National Collection indicates that this species attained a large size. One large brachial interior has a width of 70 mm. The species seems to be variable in lateral profile.

Figured hypotypes.—117767, 117768, 117769, 117770, 117771.

Horizon and locality.—Lincolnshire formation in Virginia: Near Goodwins Ferry on New River, Giles County; Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle.

Same horizon in Tennessee: $\frac{1}{2}$ mile north of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Lincolnshire formation (Hogskin member) in Tennessee: 0.4 mile northeast of Red Hill, $4\frac{1}{2}$ miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; on U. S. Highway 25E, north of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; just above *Sowerbyites* zone, $\frac{1}{2}$ mile east of Beech Grove Church, 3 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; Sally Cleveland Farm, $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 90 to 120 feet above the "Mosheim" limestone on U. S. Highway 25E, north of Hayes' house, 1 mile north of Indian Creek, Evans Ferry section, Howard Quarter (T.V.A. 162-NW) Quadrangle; upper Lincolnshire formation, $\frac{3}{4}$ mile southwest of Mount Eager Church, Hogskin Valley, Powder Springs (T.V.A. 154-SW) Quadrangle.

MACROCOELIA ELEGANTULA Cooper, new species

Plate 233, C, figures 7-12; plate 235, C, figures 5-16; plate 247, D, figures 11-13

Medium sized for the genus, attaining a width of about $1\frac{1}{2}$ inches; wider than long with the hinge varying from shorter to wider than the midwidth; sides more or less oblique; anterior margin strongly rounded; surface costellate, costellae alternating in size, about 3 to the millimeter at the front margin.

Pedicle valve strongly convex in lateral profile and with the maximum convexity at the middle; anterior profile strongly domed; beak small; umbo narrowly swollen to form a short, low fold; posterior third gently swollen, median third strongly swollen to form the most convex part; anterior slope gently convex, long and steep; lateral slopes steeper than the anterior one. Interarea short and curved; pseudodeltidium small and short. Muscle field heart shaped, occupying the posterior third; median ridges strong.

Brachial valve moderately and fairly evenly concave; deepest part at middle; sides and anterior deflected moderately toward the brachial valve. Interior with delicate cardinal process; short median ridge and slender adductor ridges, all 5 of the latter well developed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-----------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 31.4 | 29.1 | 36.0 | 28.8 ? | 6.4 |
| Paratype (117776a) .. | 28.3 | 25.6 | 38.6 | 37.8 | 7.5 |
| " (117772) ... | 27.9 | 25.8 | 31.4 | 31.2 | 7.2 |

Types.—Holotype: 117773; figured paratypes: 117772, 117774a,b, 117775a, 117776a,b; unfigured paratypes: 117775b-d, 117776c,d.

Horizon and locality.—Whistle Creek formation in Virginia: Along U. S. Highway 60 about $1\frac{1}{2}$ to 2 miles northwest of Lexington and on Whistle Creek northwest of Lexington, Lexington (15') Quadrangle.

Discussion.—This species is characterized by its small size for the genus, its fairly strong convexity, and the even, gentle concavity of the brachial valve. The species is not well known because it is quite rare. The specimens so far collected indicate some variability in the species particularly in the hinge width. No other described species of *Macrocoelia* is quite like this one. *Macrocoelia rotunda* is generally squarer and more convex and has a more concave brachial valve. *Macrocoelia plebeia* does not approach it in size or convexity.

MACROCOELIA MAGNA (Butts)

Plate 231, C, figures 9-14; plate 232, A, figures 1-7; plate 235, E, figures 17-21;
plate 236, C, figure 13; plate 239, C, figure 29

Rafinesquina magna BUTTS, Virginia Geol. Surv. Bull. 52, p. 85, pl. 86, figs. 1-4, 1942.

Shell large for the genus in adult form, moderately convex, wider than long with the greatest width at the hinge in the young but near the middle in old adults. Anterior margin broadly rounded; lateral margins generally oblique. Surface marked by costellae of unequal size, the costellae at the posterior very different in size, the larger ones separating 1 to 3 finer ones. Costellae on the anterior part of the valves becoming more uniform in size, but 1 to 3 finer costellae may be seen between the coarser ones although this is not so frequent as at the posterior of the valves. Finer costellae cancellated by strong fila. A few oblique wrinkles occurring on each side of the beak along the posterior margin.

Pedicle valve moderately convex in lateral profile with the greatest convexity located slightly anterior to the middle. Lateral slopes moderately steep; postero-lateral slopes to cardinal extremities gentle. Interarea short; approximately orthocline. Foramen minute, pseudodeltidium short, not strongly arched.

Brachial valve moderately and fairly evenly concave; posterior two-thirds gently concave but anterior third somewhat abruptly bent anteriorly. Cardinal extremities very slightly deflected in an anterior direction. Interarea short; chilidium short and low.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 60.0 | 56.7 | 78.6 | 84.0 ? | 7.5+ |
| Hypotype (117777) | 61.2 | 57.7 | 73.6 | 61.2 | 11.5 |
| " (117781a) | 46.5 | 43.9 | 55.2 | 49.1 | 6.7 |

Types.—Holotype: 98199; figured hypotypes: 117778, 117779a, 117780a, 117781a,b,d; unfigured hypotype: 117777.

Horizon and locality.—Benbolt formation in Tennessee: Along the road 1.6 miles northeast of Heiskell, Powell Station (T.V.A. 137-SE) Quadrangle; 100 yards west of the store, junction of Tennessee Highway 33 and Flint Creek, Maynardville (T.V.A. 145-SE) Quadrangle; 1½ miles northeast of Halls School, Howard Quarter (T.V.A. 162-NW) Quadrangle; ½ mile southwest of Fleanor Mill, Powell Station (T.V.A. 137-SE) Quadrangle; hillside south of Dutch, Maynardville (30') Quadrangle; ½ mile west of Dodson Creek on road from Tennessee Highway 33 to Acuff, Maynardville (T.V.A. 145-SE) Quadrangle; west side of the sharp loop on the road down Flint Creek, Powder Springs (T.V.A. 154-SW) Quadrangle.

Benbolt formation in Virginia: 100 to 150 yards north of the triangular intersection at Rye Cove and elsewhere in the vicinity of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; ⅙ mile south of Gate City, Gate City (T.V.A. 188-NE) Quadrangle; on Virginia Highway 74, 0.2 mile southwest of New Bethel Church, Hilton (T.V.A. 197-NW) Quadrangle; Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; 0.67 mile south of Tumbez, Moll Creek (T.V.A. 196-SE) Quadrangle.

Discussion.—This species is best identified by its large size; it is the largest known brachiopod occurring in the Southern Appalachians. As identified herein the shell is variable and shows considerable range in its convexity and shape. It is quite probable that more collecting will ultimately lead to the separation of more species from it. The species can be recognized in small pieces by its apparent flatness and the thin body cavity. In its complete form, however, the species is strongly convex. A good deal of the variability is due to flattening by compression. It will be noted that some of the specimens figured show fractures from compression with a consequent flattening of the shell.

Macrocoelia magna is approached in size by *M. duplistriata* (Willard) of the Lincolnshire, Hogskin member, but is much less concave in the brachial valve and is more convex in the adult form than the stratigraphically lower species.

MACROCOELIA OBESA Cooper, new species

Plate 230, C, figures 14-19

Shell moderately large for the genus, semielliptical in outline; wider than long with the greatest width slightly anterior to the hinge. Strongly concavo-convex in lateral profile. Lateral margin gently rounded; anterior margin broadly rounded. Surface multicostellate, with 2 to 6 costellae separating the

larger ones. Costellae cancellated by fila. At the front margin of an adult 5 of the larger costellae occupy a space of 5 mm.

Pedicle valve with posterior slope moderately steep in lateral profile. Median region gently convex and anterior slope moderately steep but less so than the posterior slope. Umbonal and median region inflated; lateral slopes steep. Slopes to cardinal extremities fairly gentle and slightly concave. Interarea short, nearly orthocline; pseudodeltidium small.

Brachial valve with concave umbonal region, lateral and median third of shell gently concave; anterior and lateral marginal regions geniculated gently toward the brachial valve, thus accentuating the depth of concavity of the valve. Interarea short, chilidium short and narrowly arched.

Pedicle interior with short, widely divergent but well-defined ridges that extend anterolaterally for a short distance around the posterolateral parts of the muscle area. Teeth unusually small for such a large shell. Muscle field large and flabellate. Median ridge not developed.

Interior of brachial valve with the lobes of the cardinal process having short shafts but the myophore surface moderately broad and lobate on the edge toward the pedicle valve. Callus deposit about the delicate brachiophores very slight. Median ridge low; accessory ridges moderately well developed.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|--------|-------------|-----------|
| Holotype | 35.0 | 32.7 | 40.8 ? | 39.2 | 6.8 |
| Paratype (117783b)..... | 32.7 | ? | 39.3 | 39.0 ? | ? |

Types.—Holotype: 117783a; figured paratypes: 117782a,b; unfigured paratypes: 117782c, 117783b,c.

Horizon and locality.—Arline formation in Tennessee: At $\frac{1}{4}$ mile south of McMullens, Meadow (T.V.A. 139-NW) Quadrangle; $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle; $5\frac{1}{2}$ miles southeast of Knoxville; 1 mile southeast of Fowlers Mill which is 10 miles south of Loudon, Loudon (30') Quadrangle; 1 mile east-northeast of Friendsville, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—*Macrocoelia obesa* is of moderate size for the genus, is strongly convex and fairly deeply concave. In these respects it resembles *M. bella* (for comparison see that species), *M. champlainensis*, and *M. rotunda*. The Tennessee species differs from *M. champlainensis* in having more delicate ornamentation, a more concave brachial valve, and a narrower hinge. *Macrocoelia obesa* differs from *M. rotunda* in its narrower hinge, much less convexity, and finer ornamentation.

MACROCOELIA OCCIDENTALIS Cooper, new species

Plate 233, D, figures 13-20

Large, attaining a width of nearly 2 inches; hinge variable from wider than the midwidth to equal the midwidth; cardinal extremities alate; sides subparallel to gently oblique; anterior margin broadly rounded; costellae strongly differ-

entiated, the larger ones setting off groups of several smaller ones, all beautifully cancellated by strong fila; prominent oblique wrinkles marking posterior margins.

Pedicle valve fairly evenly and moderately convex in lateral profile and with the maximum convexity at the middle; anterior profile fairly evenly and broadly convex; umbonal region gently swollen; median region swollen and full; anterior slope steeper than the lateral slopes because of a fairly abrupt bending of the anterior third toward the brachial valve. Pseudodeltidium a remnant.

Brachial valve flat to gently convex in the posteromedian region; anterior third gently deflected toward the pedicle valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 37.9 | 36.9 | 45.2 | 48.4 | 5.0 |
| Paratype (117784) | 35.9 | ? | 44.4 | ? | ? |
| " (117785b) | 29.0 | ? | 34.3 | 42.6 | ? |

Types.—Holotype: 117787; figured paratypes: 117784, 117785c; unfigured paratypes: 117785a,b.

Horizon and locality.—Yellow-weathering limestone in Roberts Mountains (1°) Quadrangle, Nev.: Above 25-foot sandstone at base of Eureka group on the crest of the Antelope Range, 3 miles south of Nine Mile Canyon; in the saddle just north of hill 8167, Martins Ridge, Monitor Range; 2 and 3 miles north of Martin Ranch; 1.9 miles N. 31° E. of Blair (=Segura) Ranch.

Discussion.—This species is distinguished by its moderately large size, wide hinge, flattish brachial valve, and generally low or moderate convexity. It is suggestive of *M. duplistriata* but does not attain the large size or fairly strong convexity of that species. In size it is similar to *M. bella*, but it is less convex and with a flatter brachial valve.

MACROCOELIA ORNATA Cooper, new species

Plate 233, A, figures 1-3; plate 236, A, figures 1-7

Shell of moderate size for the genus, attaining a width of nearly 1½ inches; hinge forming the widest part; cardinal extremities alate; sides gently rounded, oblique; anterior margin broadly rounded; surface marked by costellae formed into groups of as many as 8 fine ones bounded by stronger costellae.

Pedicle valve moderately convex in lateral profile and with the maximum convexity slightly anterior to the middle; anterior profile moderately domed; umbonal region gently swollen; median region moderately swollen; lateral slopes long and moderately gentle; anterior slope short and steep; interarea moderately long; pseudodeltidium small. Interior with long, slender median ridge; diductors with prominent thickenings along their inner edge.

Brachial valve with posterior flat to gently concave in lateral profile; maximum concavity anterior to the middle; sides and anterior margins deflected gently in the direction of the brachial valve; cardinal extremities deflected slightly toward the pedicle valve and forming a small concavity.

Measurements in mm.—Holotype, length 27.5, brachial length 25.2, midwidth 36.4, hinge width 41.2 +, thickness 6.4.

Types.—Holotype: 117789c; figured paratypes: 117788a, 117789a; unfigured paratypes: 117788b-d, 117789b.

Horizon and locality.—Little Oak formation in Alabama: At the junction of Bailey Gap and Cahaba Valley roads, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

Discussion.—This species has strongly marked ornamentation, the larger costellae standing out prominently in a mat of finer ones. The species has moderate size and moderate convexity. It is larger and more strongly ornamented than *M. elegantula*. It is wider and less convex than *M. obesa* and is smaller and more elegantly ornamented than *O. occidentalis*. Another feature of this species not seen on any other member of the genus is the flattening or even slight convexity of the posterior third of the brachial valve. This feature is pronounced on the holotype.

MACROCOELIA PLATYS Cooper, new species

Plate 231, A, figures 1-7

Shell of about medium size for the genus, wider than long; hinge equal to or narrower than the midwidth; sides gently convex, slightly oblique; anterior margin strongly rounded; costellae alternating strong and fine, 3 or less of the latter alternating with the stronger ones; 3 costellae to the millimeter at the front margin.

Pedicle valve moderately convex in lateral profile and with the maximum convexity at the middle; anterior profile broadly and moderately domed; umbo narrowly swollen and forming a low fold that extends anteriorly nearly to the middle; median region moderately swollen; anterior slope long and gentle; lateral slopes shorter and steeper than the anterior one. Pseudodeltidium short; interarea moderately long. Muscle field heart shaped, moderately large.

Brachial valve nearly flat to gently concave in lateral profile; most concave in the median region but becoming shallow to flat toward the margins.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 32.8 | 30.8 | 38.4 | 34.3 | 6.0 |
| Paratype (117790d) | 32.3 | ? | 37.6 | 30.9 | ? |

Types.—Holotype: 117790a; figured paratypes: 117790b,c; unfigured paratypes: 117790d-l.

Horizon and locality.—Lincolnshire formation in Tennessee: At Marble Bluff, 8 miles west-northwest of Loudon, Loudon (30') Quadrangle.

Discussion.—This species is characterized by moderate size and low convexity and an almost flat brachial valve. In these respects it is like *M. occidentalis*, but it is smaller and flatter than that species. It is very similar to the young of *M. duplistriata*, and more extensive collecting may ultimately prove them to be the same.

MACROCOELIA PLEBEIA Cooper, new species

Plate 121, G, figures 18, 19; plate 233, B, figures 4-6

Shell small for the genus, wider than long and with the hinge slightly wider than the midwidth; cardinal extremities auriculate. Sides slightly oblique; anterior margin somewhat narrowly rounded. Surface marked by fine costellae set off into groups by stronger costellae, 2 of the stronger costellae occurring in 1 mm. and generally setting off groups of 3 or 4 of the finer costellae.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity at about the middle; anterior profile moderately convex and with the median region narrowly humped and with long lateral slopes. Umbo narrowly convex, the convexity continuing to the swollen median region where it is dissipated in the swelling; lateral slopes long, moderately steep; posterolateral extremities flattened.

Brachial valve gently concave and with the maximum concavity at about the middle; sides and anterior margins somewhat flattened.

Brachial interior with short and low median ridge, small and narrow cardinal process lobes and adductor ridges faintly developed.

Measurements in mm.—

| | Length | Brachial length | Hinge width | Midwidth | Thickness | Height |
|----------------------|--------|-----------------|-------------|----------|-----------|--------|
| Holotype | 12.7 | 12.0 | 14.9 | 14.6+ | ? | ? |
| Paratype (117791)... | 15.8 | ? | 18.0 | 18.3 | ? | 3.6 |

Types.—Holotype: 117793a; figured paratypes: 117791, 117793b.

Horizon and locality.—Lenoir formation (*Mimella-Valcourea* zone) in Tennessee: In a small quarry between the Southern RR. tracks and U. S. Highway 11, 1½ miles southwest of Philadelphia, Philadelphia (T.V.A. 131-NW) Quadrangle; 0.9 mile west-northwest of Ellejoy Church, Wildwood (T.V.A. 147-SE) Quadrangle; 45 feet above the base of the Lenoir, 0.1 mile southwest of triangulation mark 37SH, Wildwood (T.V.A. 147-SE) Quadrangle.

Discussion.—This is a small species of moderate convexity. It is smaller and more quadrate than *M. elegantula* and is quite unlike any of the other species. It suggests *Öpikina*, but the brachial valve is not geniculated.

MACROCOELIA ROTUNDA Cooper, new species

Plate 234, A, figures 1-5

Rafinesquina cf. *R. champlainensis* BUTTS (not Raymond), Virginia Geol. Surv. Bull. 52, p. 85, pl. 86, figs. 5-7, 1942.

Shell large for the genus, attaining a length of more than 2 inches; slightly wider than long; sides gently rounded; subparallel; hinge shorter or wider than the midwidth; cardinal extremities slightly auriculate. Anterior margin narrowly rounded. Costellae moderately strong, well differentiated into coarse and fine.

Pedicle valve strongly convex in lateral profile and with the maximum convexity slightly anterior to the middle; anterior profile strongly domed, with

steep sides; beak small, umbo swollen; median region strongly inflated; anterior slope steep. Interarea moderately long and curved. Pseudodeltidium nearly obsolete.

Brachial valve most deeply concave in the median region. Sides and anterior sloping steeply toward the middle; cardinal extremities deflected toward the pedicle valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 35.5 | 33.0 | 38.4 | 32.2 | 8.0 ? |
| Paratype (98200b) | 50.3 | 46.2 | 51.4 | 41.0 | 11.4 |
| " (98200c) | 36.9 | 33.8 | 40.2 | 40.6 | ? |
| " (117794b) | 65.6 | 60.0 | 72.6 | 71.0 | 16.4 |

Types.—Holotype: 98200a; figured paratype: 98200c; unfigured paratypes: 98200b, 117794a,b.

Horizon and locality.—Benbolt formation in Virginia: At Green Valley Church, 3 miles southeast of Lebanon, Brumley (T.V.A. 205-SE) Quadrangle; several localities in the vicinity of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This is another gigantic form as large as *M. magna*, but it is represented in the collections by only a few specimens. Consequently, all the details for this species cannot be listed at the present time. It is characterized by strong convexity and has a deeply concave brachial valve. The cardinal extremities are marked by small ears. The square outline and rotundity are characteristic. No other described species is so strongly rotund. It differs from *M. magna* in its greater depth, thicker body region, and squarer outline. A specimen sectioned through the middle shows a thick marginal rim on the anterior margin of the brachial valve. This anterior marginal brim is one of the prime distinctions between *Macrocoelia* and *Öpikina*, the latter being thickened at the place of geniculation and having a thin trail anterior to the rim.

MACROCOELIA RUEDEMANNI (Salmon)

Rafinesquina alternata RUEDEMANN (not Emmons), New York State Mus. Bull. 49, p. 16, pl. 2, fig. 1, 1901.

Öpikina ruedemanni SALMON, Journ. Paleont., vol. 16, No. 5, p. 597, pl. 87, figs. 31-33, 1942.

Types.—Holotype: Columbia Univ. 25909; paratype: Columbia Univ. 25916.

Horizon and locality.—Rysedorf conglomerate in New York: At Rysedorf Hill, near Albany.

MACROCOELIA sp. 1

This is a moderate-sized species, slightly wider than long as usual in the genus. Hinge wider than the midwidth and cardinal extremities pointed. Only pedicle valves are so far known; consequently, no effort is made to describe the species. The lateral profile is moderately convex with the maximum convexity slightly anterior to the middle. The anterior profile is strongly domed. The umbo is swollen broadly but is not continued anteriorly as a fold. Lateral slopes and

anterior slope are steep. The costellae are differentiated on the posterior and median parts but are more nearly equal in size at the anterior.

Measurements in mm.—117796a, length 27.5, midwidth 28.2, hinge width 33.3, height 7.7.

Described specimens.—117796a,b.

Horizon and locality.—Lenoir formation in Tennessee: 2 miles southeast of Whitesburg, Bulls Gap (T.V.A. 171-SE) Quadrangle.

PIONOMENA Cooper, new genus

(Greek *pion*, fat; *mene*, crescent)

Shells generally small, attaining a length of about $\frac{3}{4}$ inch; compressed biconvex; hinge straight, generally not equal to the maximum width which is near the middle. Anterior commissure rectimarginate to gently sulcate; surface multicostellate, costellae varying in size, usually somewhat fasciculate.

Pedicle interior with moderately large teeth and long, flat dental ridges; muscle area suboval to cordate; posteriorly surrounded by the sides of the delthyrial cavity and 2 long, thin, curving plates laid against the inner side of the dental ridge. Pseudodeltidium narrowly convex; foramen small.

Brachial valve with well-developed chilidium; cardinal process bilobed, small and delicate. Sockets formed by short, wide cups formed by a thin and delicate plate.

Genotype.—*Pionomena neumani* Cooper, new species.

Discussion.—This genus is characterized by its biconvex profiles, the fasciculate ornamentation, and the presence of strong dental ridges in the pedicle valve, which simulate thin dental plates. The genus differs from *Strophomena* and *Rhipidomena* in its biconvex profiles, strongly fasciculate ornamentation, and the development of thin, curving ridges laid against the inside surface of the teeth.

PIONOMENA ? DUBIA Cooper, new species

Plate 246, E, figure 15

Undetermined genus related to *Rafinesquina*? Butts, Virginia Geol. Surv. Bull. 52, p. 67, pl. 80, figs. 1-3, 1942.

Shells attaining a width of slightly less than an inch; subrectangular in outline, biconvex in profile; hinge slightly less than the midwidth; cardinal extremities obtuse; anterior margin broadly rounded; surface multicostellate, costellae alternating, 1 or more fine costellae with stronger ones between, about 4 to the millimeter at the front margin, all strongly cancellated by strong concentric fila.

Pedicle valve with lateral profile gently convex and the maximum convexity at about the middle; anterior profile broadly convex and with the median region subcarinated. Umbo narrowly convex, the convexity continued anteriorly at least to the middle as a low, broadening fold; umbonal slopes long and gentle; median region swollen; anterior slope long and gentle. Apex perforate.

Brachial valve gently convex in lateral profile and with the maximum con-

vexity at the middle; anterior profile broad and gently convex; umbo marked by a narrow and shallow sulcus; median region moderately swollen; lateral and anterior slopes short but gentle. Cardinal process bilobed as usual in the genus.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thick-ness | Height |
|-----------------------|--------|-----------------|----------|-------------|------------|--------|
| Holotype | 12.6 | ? | 17.2 | 16.0 | ? | 2.3 |
| Paratype (123277a) .. | 15.0 | ? | 21.3 | 19.4 | ? | 3.1 ? |
| " (123277b) .. | ? | 13.4 | 19.5 | 17.4 | ? | 1.9 |

Types.—Holotype: 98222; unfigured paratypes: 123277a,b.

Horizon and locality.—Effna formation in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This species differs from the others described herein in the character of the ornamentation. It is wider and somewhat larger than *P. neumani* and has much finer ornamentation. Indications are that this species is definitely a strophomenoid with fairly strongly convex valves and with the cancellated ornament characteristic of young strophomenoids.

PIONOMENA NEUMANI Cooper, new species

Plate 265, D, figures 7-11

Shell attaining a length of about 0.6 inch; subcircular to subquadrate in outline, with the greatest width at about the middle; hinge narrower than the greatest shell width; sides nearly straight to gently rounded; anterior margin strongly rounded; costellae of unequal size, about 21 in 5 mm. at the front margin, the stronger ones separated by 1 to 5 of the finer costellae.

Pedicle valve very gently convex in lateral and anterior profiles; umbonal region marked by a narrow fold that extends anteriorly to beyond the middle where it disappears in the general convexity; flanks of fold gently concave and extending by long, gentle slopes to the margins. Anterior slope nearly flat.

Brachial valve gently convex in anterior and lateral profiles; umbo marked by a shallow and narrow sulcus that widens anteriorly and reaches nearly to the front margin. Flanks bounding sulcus gently swollen; posterolateral slopes to flattened cardinal extremities short and moderately steep.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 14.1 | ? | 15.7 | 13.9 | ? |
| Paratype (" " 117756b) .. | 14.1 | ? | 15.6 | 13.9 | ? |
| " (brachial valve 117756c) . | ? | 12.0 | 14.6 | 12.9 | ? |

Types.—Holotype: 117756a; figured paratypes: 117755, 117756b-d.

Horizon and locality.—New Market formation (in the top 12 feet) in Williamsport (15') Quadrangle, Maryland: $\frac{1}{2}$ mile southwest of Hicksville; 3 miles N. 10° E. of Wilson; $\frac{3}{4}$ mile north of St. Pauls Church, west of Wilson.

Same formation in Pennsylvania: 1 mile west-southwest of Marion, Chambersburg (15') Quadrangle.

Same formation in Virginia: On Hiatt Run, 3 miles north of Winchester, Winchester (15') Quadrangle.

Elway formation in Giles County, Virginia: On Sinking Creek, 12 miles northwest of Blacksburg.

Same formation in Tennessee: On U. S. Highway 25W, 4.7 miles south of Clinton, Powell Station (T.V.A. 137-SE) Quadrangle.

Lincolnshire formation in Virginia: On the Norfolk and Western RR. $\frac{1}{2}$ mile upstream from Benton Station, Giles County.

Discussion.—This species is more strongly costellate than *P. ? dubia*. The pedicle valve is marked medianly by a narrowly folded umbo and the brachial valve has a corresponding sulcus, both features being better developed than on corresponding parts of the *Effna* species. It is larger and more finely fasciculate than *P. pulchra* from the Grazier limestone of Pennsylvania.

PIONOMENA PULCHRA Cooper, new species

Plate 248, C, figures 4-7

Shell small, unequally biconvex, the pedicle valve having the greater convexity. Hinge narrower than the greatest width which is at about the middle. Sides and anterior margin well rounded. Surface fascicostellate.

Pedicle valve somewhat carinate umbonally but with flattened to somewhat concave lateral areas. Umbo continued anteriorly as a low fold which does not meet the anterior margin. Brachial valve gently convex and marked medially by a shallow sulcus best defined in the posterior third but variable.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (brachial valve) | ? | 10.2 | 13.3 | 10.5 | ? |
| Paratype (pedicle valve 123275c) .. | 10.8 | ? | 11.6 | 10.0 | ? |

Types.—Holotype: 123275b; figured paratype: 123275c; unfigured paratype: 123275a.

Horizon and locality.—Carlism formation (base) = Grazier member of the Hatter formation, in Pennsylvania: On Elk Run, 3 miles southwest of Nealmont, Tyrone (15') Quadrangle.

Discussion.—This species is suggestive of *P. neumani* but is smaller, has a flatter brachial valve and more distantly fasciculate ornamentation.

Genus ÖPIKINA Salmon, 1942

Öpikina SALMON, Journ. Paleont., vol. 16, No. 5, p. 589, 1942.

ÖPIKINA ALATA Cooper, new species

Plate 246, C, figures 5-11

Shell small for the genus, wider than long; hinge forming the widest part; cardinal extremities alate; sides oblique; anterior margin narrowly rounded; costellae numbering 5 or 6 at the front margin.

Pedicle valve with moderately convex visceral region, rounded geniculation, and steep, moderately long trail. Angle of geniculation about 96° ; geniculation occurring 5 to 6 mm. anterior to the beak; sides steep; umbo narrowly convex; interarea short.

Brachial valve with gently concave visceral region; deepest anterior to the middle just below the steep trail; sides moderately deflected toward the brachial valve; anterior margin strongly deflected; internal septa mostly covered by adventitious shell.

Measurements in mm.—Holotype, length 10.5, brachial length 9.3, midwidth 13.6, hinge width 16.4, thickness 2.0?, height 4.8, trail length 7.0.

Types.—Holotype: 117797c; figured paratype: 117797b; unfigured paratype: 117797a.

Horizon and locality.—Edinburg formation (*Nidulites* zone) in Strasburg (15') Quadrangle, Virginia: 100 yards south of the entrance to Battlefield Crystal Caverns on U. S. Highway 11, 1 mile north of Strasburg; along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg.

Discussion.—This species is characterized by the ears on the cardinal extremities, small size, and geniculation near the middle. The species may be confused with *O. dorsatiformis* and *O. parvula* which has about the same size. It differs from the former in being much less convex and in not geniculating at so early a stage of growth as *O. dorsatiformis*. It differs from *O. parvula* in having its place of geniculation at the middle rather than anterior to the middle and in having more pronounced ears.

ÖPIKINA BELLULA Cooper, new species

Plate 242, D, figures 14-25

Small for the genus, subrectangular, wider than long with the hinge forming the widest part; cardinal extremities subauriculate; sides gently rounded, gently oblique; anterior margin narrowly rounded; surface strongly costellate, costellae on visceral area with strong costellae separated by numerous fine ones but trail marked by strong costellae with the finer ones distinctly subordinate; 2 or 3 of the stronger costellae in 1 mm. at the front margin. Strong wrinkles on posterior margins.

Pedicle valve unevenly convex in lateral profile, the visceral region being nearly flat to gently convex but the front third strongly angulated about 10 mm. anterior to the beak; angle of geniculation about 110° ; umbo narrowly swollen, the swelling continued anteriorly as a low fold. Visceral disk region gently swollen; anterior and lateral slopes short and steep.

Brachial valve with visceral region concave and with lateral and anterior margins fairly strongly deflected toward the brachial valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height | Trail length |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|--------------|
| Holotype | 15.3 | ? | 17.8 | 19.2 | ? | 5.0 ? | 7.0 ? |
| Paratype (117799b).... | 14.9 | 13.7 | 18.0 | 19.0 | ? | 5.0 | 7.5 |

Types.—Holotype: 117799a; figured paratypes: 117799b-e.

Horizon and locality.—Edinburg formation (*Cyrtonotella* zone) in Strasburg (15') Quadrangle, Virginia: In the ravine at the switch about $\frac{1}{8}$ mile east of Strasburg Junction; Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg.

Shippensburg formation (*Echinosphaerites* zone) in Maryland: On the west bank of Conococheague Creek on U. S. Highway 40, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—This species is characterized by its moderate size, low convexity, and fairly strong costellae. The general form of the shell is suggestive of *Ö. speciosa* and *Ö. formosa*, but these are larger and more strongly geniculated species. It is more convex and more strongly ornamented than *Ö. minnesotensis*. *Öpikina varia* from Alabama is somewhat similar in size and form but is more strongly geniculated and the interior of the brachial valve has the septa more strongly developed.

ÖPIKINA CLARA (Okulitch)

Rafinesquina clara OKULITCH, Canadian Field-Nat., vol. 49, No. 6, p. 97, pl. 1, fig. 1, 1935.

Öpikina clara (Okulitch) SALMON, Journ. Paleont., vol. 16, No. 5, p. 597, pl. 87, fig. 28, 1942.

Type.—Holotype: Peter Redpath Mus.

Horizon and locality.—Leray = Chaumont in Quebec: At Pointe Claire.

ÖPIKINA DORSATIFORMIS Cooper, new species

Plate 237, B, figures 20-28; plate 242, B, figures 6-10

Small for genus, subquadrate; length and width about equal; sides gently rounded, subparallel; anterior margin narrowly rounded; hinge narrower than the midwidth; cardinal extremities rounded. From 3 to 5 costellae in 1 mm. at the front margin; short wrinkles appear on the posterior margin.

Lateral profile strongly convex; visceral region not strongly differentiated from the trail; geniculation occurring about 5 mm. anterior to the beak; visceral region gently convex and provided with obscure concentric wrinkles; angle of geniculation less than a right angle; trail long and moderately convex; lateral slopes precipitous.

Brachial valve deeply concave and deepest at the middle; umbo sulcate, the sulcus extending for a short distance anteriorly; sides and anterior margin strongly deflected toward the brachial valve and forming a high rim around the median concavity.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height | Trail length |
|----------------------|--------|-----------------|----------|-------------|-----------|--------|--------------|
| Holotype | 13.6 | 11.6 | 14.2 | 11.7 | 3.9 | 7.4 | 17.5 |
| Paratype (117800)... | 10.4 | ? | 12.4 | 11.9 | ? | 4.7 | 10.0 |

Types.—Holotype: 117801; figured paratype: 117800.

Horizon and locality.—Edinburg formation (*Cyrtonotella* and *Nidulites* zones) in Strasburg (15') Quadrangle, Virginia: Just east of a small ravine on

the north side of the road along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg; in the ravine at the switch about $\frac{1}{8}$ mile east of Strasburg Junction.

Discussion.—This species is recognized by its small size and nearly hemispherical lateral profile. It is most like *Ö. dorsata* from the Kuckers formation of Estonia but differs in having squarer outline and wider hinge than the Estonian species. Furthermore, the Estonian species is somewhat more convex and smaller.

ÖPIKINA ? DUBIA Cooper, new species

Plate 246, D, figures 12-14

Shell small, length and width about equal; sides nearly parallel; hinge slightly wider than or equal to the midwidth; anterior margin narrowly rounded; surface costellate, 4 or 5 costellae in 1 mm. at the front margin.

Pedicle valve with lateral profile uneven, the umbonal region slightly convex, the area just anterior to the middle slightly concave, and the marginal regions abruptly bent in the direction of the brachial valve; anterior profile broadly and slightly convex. Umbonal region gently convex; region just posterior to the margin gently concave; margins bent toward the brachial valve narrowly and abruptly; lateral and anterior slopes short and precipitous.

Brachial valve with concave umbo but gently convex visceral region; margins bent abruptly toward the brachial valve; postmarginal areas narrowly concave.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype (pedicle valve) . . | 14.4 | ? | 16.2 | 16.0 | ? | 2.5 |
| Paratype (brachial valve) . | ? | 13.4 | 14.6 | 14.9 | ? | ? |

Types.—Holotype: 123274a; figured paratype: 123273a.

Horizon and locality.—Botetourt formation in Virginia: In Lexington (15') Quadrangle, 1 mile northwest of Lexington; 2 miles south of Stag Back Mountain, 7 miles north-northeast of Lexington. Near Cedar Grove Church and School, $1\frac{1}{2}$ miles southeast of Harrisonburg, Harrisonburg (15') Quadrangle.

Discussion.—The almost flat to gently concave lateral profile and strong marginal geniculation of this species separate it from all other known species of the genus except *Ö. nasuta* (which see). No interiors of this are known. The generic assignment is therefore questioned because of its peculiar form.

ÖPIKINA EXIMIA Cooper, new species

Plate 240, B, figures 8-18

One of the largest of known species; subquadrate, length and width nearly equal; sides gently curved, subparallel; hinge forming the widest part; cardinal extremities auriculate; anterior margin narrowly rounded. Costellae well differentiated, 2 of the stronger ones in 1 mm. at the front margin. Strong wrinkles on posterior margins.

Pedicle valve of uneven convexity in lateral profile, the posterior two-thirds gently convex and the anterior third fairly strongly geniculated; anterior profile

strongly domed; angle of geniculation varying from 100° to 120° , and formed about 20 mm. anterior to the beak. Umbo broadly and gently swollen; beak inconspicuous; visceral region gently inflated; lateral slopes long and steep; anterior slope long and steep. Muscle field large, occupying nearly half the interior. Pseudodeltidium small and having a median depression.

Brachial valve deeply concave just anterior to the middle; visceral region gently concave; posterolateral extremities flattened at the ears; sides and anterior margin strongly deflected toward the brachial valve; umbo broadly but gently concave. Interior with septa mostly buried by adventitious shell substance; the 2 outside septa short and thick; cardinal process large and thick; subperipheral rim thick.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height | Length of trail |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|-----------------|
| Holotype | 24.6 | 23.0 | 28.8 | 31.6 | 3.8 | 7.5 | 8.0 |
| Paratype (117806b)... | 23.3 | 21.7 | 25.2 | 26.3 | ? | 9.5 | 11.0 |
| " (117803).... | 29.0 | 26.5 | 32.0 | 35.9 | 6.3 | 12.1 | ? |

Types.—Holotype: 117806a; figured paratypes: 117802, 117803, 117804a, 117805, 117806b; unfigured paratypes: 117804b, 117806c,d.

Horizon and locality.—Lebanon formation in Tennessee: From the *Doleroides* zone on U. S. Highway 70N opposite Fairview Service Station, $\frac{1}{2}$ mile west of Rome; east end of the bridge on U. S. Highway 70N over Round Lick Creek, Rome, Smith County. Columbia, Maury County. On U. S. Highway 41, $\frac{3}{4}$ mile south of Knox Branch, 9 miles southeast of Murfreesboro; 3 miles east of Murfreesboro; U. S. Highway 241, $1\frac{1}{2}$ miles (airline) southwest of Christiana, Rutherford County. Lebanon, Wilson County.

Camp Nelson formation in Kentucky: At High Bridge, Harrodsburg (30') Quadangle.

Discussion.—This is a large form that approaches some species of *Macrocoelia* in size, but strong geniculation and characteristic rim in the brachial valve indicate its affinity to *Öpikina*. The species is smaller and more concave than *Ö. maja*, the largest known species of *Öpikina*. It is more convex than, but almost as large as *Ö. planulata*.

The pseudodeltidium of this species is of interest because it is concave and has a depressed line running along its length from its apex to the base.

ÖPIKINA EXPATIATA Cooper, new species

Plate 24I, A, figures 1-8

Shell large, wider than long, subquadrate to subrectangular; hinge variable, ranging from wider to less than the midwidth; sides gently rounded, subparallel. Costellae variable, differentiated into strong and fine; several strong costellae may separate stronger ones on the posterior parts, but at the front margin the costellae may be crowded and poorly differentiated to alternating fine and strong and the costellae somewhat distant; 3 or 4 costellae occupying 1 mm. at the front margin.

Pedicle valve moderately convex in lateral profile, the maximum convexity located anterior to the middle; anterior profile broadly domed; valves not geniculated but curved just anterior to the middle, the angle of the curvature being about 130° . Beak small, umbo marked by a poorly defined narrow, low fold; posterior half gently swollen; anterior half strongly swollen and with a long steep anterior slope; lateral slopes long and steep. Interarea moderately long; pseudodeltidium of many specimens marked by groove. Interior not known.

Brachial valve gently concave, most concave at about the middle; sides and anterior margin moderately to strongly deflected toward the brachial valve. Posterolateral region moderately flattened. Interior with unusually low septa and ridges; brachiophores small and bladelike and with only a modest development of the socket cups; subperipheral rim strong in old shells.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 23.4 | 22.3 | 30.2 | 29.1 | 3.8 | 7.5 |
| Paratype (117807b)..... | 19.0 | 17.5 | 20.8 | 23.6 | 2.8 | 4.6 |
| " (117807d)..... | 19.2 | 18.1 | 22.3 | 22.7 | 3.0 | 6.0 |
| " (117807e)..... | 19.9 | 17.7 | 23.4 | 27.1 | 2.5 | 5.0 |
| " (117807f)..... | 23.0 | 21.4 | 26.8 | 28.9 | ? | 6.1 |

Types.—Holotype: 117807a; figured paratypes: 117807b,c; unfigured paratypes: 117807d-f.

Horizon and locality.—Bromide formation (Mountain Lake member) in Murray County, Oklahoma: On the east side of the road cut on Oklahoma Highway 18, NW $\frac{1}{4}$ sec. 11, T. 1 S., R. 3 E., 1.8 miles south of Sulphur; Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W.

Discussion.—This species is characterized by its fairly large size, moderate but uneven convexity, width greater than the length, and the broad, open concavity of the brachial valve. This species differs from *Ö. formosa* in its greater size, more openly concave brachial valve, more subdued character of the septa of the brachial interior, and less pronounced ears. It is similar in size and form to *Ö. lirata* from the Decorah (Ion) of Minnesota but is more convex anteriorly, has a longer interarea, and is less deeply concave. Some specimens suggest *Ö. speciosa*, but that species is generally less wide, more strongly geniculated, and more convex anteriorly.

ÖPIKINA EXTENSA Cooper, new species

Plate 243, A, figures 1-8

Shell moderately large for the genus, wider than long and with extended and alate hinge; cardinal extremities acute; sides strongly oblique; anterior margin broadly rounded; costellae of pedicle valve stronger and more even than those of the brachial valve and numbering 3 to the millimeter; costellae of brachial valve strongly differentiated into fine and strong, 2 of the latter in 1 mm. at the margin and separated by 2 or 3 of the finer costellae. Posterior margins with oblique wrinkles.

Pedicle valve moderately convex in lateral profile with the maximum convexity in the anterior third; posterior two-thirds gently convex; anterior profile broadly and gently convex; umbo narrowly swollen to form a short, low fold; median region gently swollen; anterior third moderately swollen and bent toward the brachial valve to form a short and steep anterior slope; lateral slopes long and gentle.

Brachial valve gently concave, the maximum concavity at about the middle; posterolateral regions flattened to form the ears; sides moderately, and anterior margin fairly strongly, bent in the direction of the brachial valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 19.8 | 18.4 | 29.5 | 40.6 | 4.7 | 6.9 |
| Paratype (123268a) | 19.8 | 18.7 | 27.0 | ? | 3.6 | 6.3 |

Types.—Holotype: 123268b; figured paratype: 123268a; unfigured paratype: 123268c.

Horizon and locality.—Bromide formation (Pooleville member) in Oklahoma: 3 miles northeast of Springer, Carter County.

Discussion.—This species is unlike any other described herein in the great lateral extension of the hinge to form long, blunt ears. The species, by the similarity of its ornamentation to that of *Ö. formosa* and *expatiata*, is undoubtedly related to those species.

ÖPIKINA FORMOSA Cooper, new species

Plate 243, B, figures 9-17; plate 243, C, figures 18-28

Shell of about medium size for the genus, subquadrate, slightly wider than long; hinge equal to or slightly less than the midwidth; cardinal extremities nearly a right angle; sides subparallel; anterior margin somewhat narrowly rounded. Costellae strong, alternating fine and strong on the posterior and not strongly differentiated at the front margin where 4 costellae appear in the space of 1 mm.

Pedicle valve unevenly to fairly evenly convex in lateral profile, the maximum convexity just anterior to the middle; anterior profile strongly domed. Beak prominent; umbo narrowly swollen and forming a low, short fold; posterior half gently to moderately swollen; angle of geniculation varying from 110° to 120°; anterior slope or trail steep and nearly flat to gently convex in profile; sides steep. Interior not known.

Brachial valve gently concave in the posterior half, more deeply concave anterior to the middle where the valve is deflected steeply toward the brachial valve; umbo somewhat broadly concave; sides fairly strongly deflected in the direction of the brachial valve. Interior with thickened and beaded subperipheral rim; 5 septa well developed; cardinal process stout and long.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 19.3 | 18.0 | 22.5 | 23.9 | 3.5 | 6.3 |
| Paratype (123272c)..... | 13.0 | 12.3 | 14.5 | 16.8 | 1.7 | 2.9 |
| " (117809)..... | 20.0 | 18.0 | 23.1 | 22.4 | 4.7 | 8.0 |
| " (117810c)..... | 19.1 | 17.7 | 21.9 | 20.8 | 3.9 | 6.3 |
| " (117811a)..... | 18.9 | 17.3 | 22.8 | 20.9 | 3.9 | 6.2 |
| " (117811d)..... | 15.0 | 14.2 | 17.6 | 17.2 | 2.5 | 3.8 |

Types.—Holotype: 123272a; figured paratypes: 117808, 123269b, 123270a, 123271a, 123272b; unfigured paratypes: 117809, 117810a-d, 117811a-d,e,f, 117813, 123272c-f.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone) in Oklahoma: At Rock Crossing, center sec. 35, T. 5 S., R. 1 E., Criner Hills, $\frac{1}{4}$ mile west of U. S. Highway 77, sec. 25, T. 2 S., R. 1 E.; West Spring Creek, 3 miles east of Pooleville; NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., Criner Hills; Carter County. Quarry on the east side of Oklahoma Highway 18, center SW $\frac{1}{4}$ sec. 12, T. 1 S., R. 3 E., 2 miles south of Sulphur, Murray County; Spring Creek, N $\frac{1}{2}$ sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is most like *Ö. speciosa* of all those described herein but differs in being less convex, in having more pronounced ears, and in having a shorter anterior trail.

ÖPIKINA GLABELLA Cooper, new species

Plate 239, A, figures 1-7; plate 247, C, figures 7-10

Medium sized for the genus, wider than long; subrectangular in outline and with the hinge equal to or greater than the midwidth; sides gently rounded; anterior margin broadly rounded; surface with well-differentiated costellae, 5 to the millimeter at the front margin. Oblique wrinkles present on posterior margin.

Pedicle valve evenly and strongly convex in lateral profile, no marked position of geniculation detectable; maximum convexity at or near the middle; anterior profile strongly domed; beak prominent; umbo narrowly swollen and forming a small eminence anterior to the beak; median region strongly swollen; sides and anterior slope steep. Interarea short. Interior unknown.

Brachial valve fairly deeply concave, the greatest depth just anterior to the middle; posterior half gently concave but the umbo and median region marked by a shallow sulcus. Sides moderately deflected but anterior margin strongly deflected toward the brachial valve.

Measurements in mm.—Holotype, length 15.9, brachial length 15.0, midwidth 17.7?, hinge width 16.9?, thickness 3.9, height 6.5.

Types.—Holotype: 123267b; figured paratype: 123267a; unfigured paratype: 123267c.

Horizon and locality.—Arline formation (upper) in Tennessee: On north side of old road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is characterized by having its length and width

nearly equal, strong convexity with the maximum curvature at about the middle and corresponding deep concavity. This species differs from *Ö. matutina*, another species from about the same horizon, in being larger, squarer, and deeper. It is larger and not so convex as *Ö. dorsatiformis* but is smaller and more convex than *Ö. bellula*.

ÖPIKINA GREGARIA Cooper, new species

Plate 238, B, figures 8-18

Of about medium size for the genus, wider than long; hinge wider than or less than the midwidth; cardinal extremities varying from a slightly obtuse angle to acute and auriculate; sides subparallel to oblique; anterior margin somewhat narrowly to broadly rounded; ornamentation fine and subdued, variable, that of the brachial valve somewhat finer than that of the pedicle valve, the costellae numbering about 4 to the millimeter. Posterior margins with oblique wrinkles.

Pedicle valve unevenly convex in lateral profile, the maximum convexity located just anterior to the middle; anterior profile broadly but moderately domed. Posterior two-thirds gently convex; anterior third bent strongly but broadly toward the brachial valve to form an angle of geniculation of 100° to 115° . Anterior slope rounded, short and steep; lateral slopes longer than the anterior one and less steep; broadly but gently swollen. Interarea short.

Brachial valve fairly strongly concave in the median and posterior regions, most deeply concave just anterior to the middle; umbo concave; sides and anterior margin moderately curved toward the brachial valve. Interior with moderate and beaded rim; cardinal process small; septa low and subdued.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 18.0 | 17.2 | 21.4 | 20.3 | 3.5 | 6.2 |
| Paratype (117814a) | 17.0 | 15.5 | 19.1 | 25.0 | 2.7 | 5.0 |
| " (117814c) | 17.3 | 16.9 | 22.1 | 25.4 | 3.2 | 5.7 |
| " (117814d) | 13.9 | 13.2 | 16.4 | 16.0 | 1.9 | 3.7 |

Types.—Holotype: 117814b; figured paratypes: 117814a,c-e; unfigured paratype: 117814f.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: On Oklahoma Highway 99, 3 miles south of Fittstown, Pontotoc County; just west of the road on Russell Ranch, SE $\frac{1}{4}$ sec. 3, T. 2 S., R. 3 E., Murray County.

Discussion.—This species is characterized by moderate size, moderate convexity located anterior to the middle, fairly prominent ears, and unusually delicate ornamentation. In the latter respect it differs from *Ö. formosa* and *Ö. expatata*, both Oklahoma species. It also differs from both of these in form and degree of geniculation. It differs from *Ö. septata* in having a more rounded geniculation and greater convexity. *Öpikina gregaria* is shaped differently from *Ö. transversa*, less strongly geniculated and generally with less prominent ears.

ÖPIKINA INQUASSA (Sardeson)

Plate 245, B, figures 9-12

Strophomena inquassa SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 334, pl. 5, figs. 22-24, 1892.*Öpikina inquassa* (Sardeson) SALMON, Journ. Paleont., vol. 16, No. 5, p. 593, pl. 87, figs. 12-14, 1942 (for complete synonymy).*Type*.—Hypotype: 24206.*Horizon and locality*.—Decorah formation (Guttenburg member, *Stictopora* bed) in Minnesota: At Minneapolis.**ÖPIKINA LIRATA Cooper, new species**

Plate 247, F, figures 17-25

Shell large for the genus, subrectangular in outline, wider than long and with a variable hinge; sides moderately rounded; anterior margin broadly rounded; costellae differentiated as usual in the genus, 2 to 4 at the front in 1 mm., 1 to 3 of these usually of the finer grade. Valves often plaited by interruptions in growth stages.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity located at the middle or slightly anterior to the middle; anterior profile moderately to strongly and broadly domed. Not strongly geniculate, the bending usually fairly broad and rounded; posterior gently convex; anterior slope convex, long and steep; lateral slopes less steep than the anterior one. Umbonal region somewhat swollen. Pseudodeltidium small, depressed inward. Interarea short. Muscle field large, occupying about half the inner surface.

Brachial valve deeply concave in the median region; posterior region gently concave; side moderately folded toward the brachial valve; anterior margin strongly deflected toward the brachial valve. Interior with subdued septa, stout cardinal process.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 23.2 | 21.7 | 30.0 | 24.5 | 3.6 | 7.9 |
| Paratype (117816a)..... | 24.2 | 22.8 | 32.0 | 29.0+ | 3.8 | 7.8 |
| " (117816b)..... | 23.7 | 22.6 | 28.3 | 24.4 | 2.7 | 7.9 |

Types.—Holotype: 117816d; figured paratypes: 117816a-c,f; unfigured paratypes: 117816e,g.

Horizon and locality.—Decorah formation (Ion member) in Minnesota: From a road cut 1.1 miles east of U. S. Highway 52 on the south edge of Cannon Falls; Fountain and Kenyon, Goodhue County. Twin City Brick Quarry, southeast St. Paul.

Discussion.—This is a fairly large and strongly convex shell broadly and deeply open when viewed from the side of the brachial valve. It is suggestive of *Ö. expatiata*, and comparison between the two is made under that species. Compared with other Minnesota species it is larger than *Ö. inquassa* and is less pronouncedly geniculate than that species.

ÖPIKINA MAJA Cooper, new species

Plate 236, D, figure 14

Shell large for the genus, subquadrate in outline, with the length and width nearly equal in the adult; sides gently rounded, subparallel; anterior margin somewhat narrowly rounded; hinge narrower than the midwidth in the adult but wider than the midwidth in young; cardinal extremities rounded. Four to six costellae in 1 mm. at the front margin; posterior margin with oblique wrinkles.

Pedicle valve fairly evenly convex in lateral profile, with the maximum convexity just anterior to the middle; umbonal and posterior regions swollen; anterior profile strongly domed and with long, moderately steep sides. Narrow swelling at umbo. Median region strongly swollen; anterior slope gently convex in profile, long and steep; interarea short. Interior with large flabellate muscle field occupying less than half the inner surface.

Brachial valve with maximum depth at or just anterior to the middle; posterior half gently concave; sides and anterior margin moderately bent in the direction of the brachial valve.

Measurements in mm.—Holotype, length 42.8, brachial length 40.2, midwidth 43.1, hinge width 32.5?, thickness 9.7, height 17.7.

Types.—Holotype: 117819; unfigured paratype: 117820a.

Horizon and locality.—"Lebanon formation"=Ridley formation in Kensington (T.V.A. 206-SE) Quadrangle, Georgia: From a road cut on U. S. Highway 27, on the north bank of Chickamauga Creek, 1½ miles northeast of Pond Spring.

Discussion.—This is the largest of the species referred to *Öpikina*. Although the proportions approach *Macrocoelia*, the geniculation of the brachial valve as revealed by a brachial interior (117820a) is like that characteristic of *Öpikina*.

ÖPIKINA MATUTINA Cooper, new species

Plate 245, C, figures 13-20

Small for the genus, subrectangular in outline; wider than long and with the hinge forming the widest part; cardinal extremities acute to auriculate; sides gently rounded; anterior margin broadly rounded; surface costellate as usual in the genus, about 6 to the millimeter at the front margin. Oblique wrinkles present on posterior margin.

Pedicle valve unevenly convex in lateral profile with the visceral region occupying the posterior two-thirds, gently convex; angle of geniculation about 100°; trail short, steep, and nearly flat in profile; umbo narrowly folded at the beak and forming a short, indistinct fold; interarea short. Interior with large muscle field; diductors subflabellate.

Brachial valve with visceral region flattened but anterior margin strongly deflected toward the brachial valve to form a deep concavity; sides much less strongly deflected than the anterior margin; umbo sulcate. Interior with usual septa thickened and partly covered by adventitious shell.

Measurements in mm.—Holotype, length 12.1, brachial length 11.0, midwidth 14.2, hinge width 15.0, thickness 2.9, height 4.7, trail length 6.0.

Types.—Holotype: 117817a; figured paratype: 117817b; unfigured paratype: 117817c.

Horizon and locality.—Arline formation in Virginia: In Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Discussion.—This is one of the earliest members of this genus yet found. The species is small, geniculate in the anterior third, and has a diamond-shaped muscle area in the pedicle valve. It is similar to *Ö. parvula* but differs in having pronounced ears, geniculation farther anterior to the beak, and a flatter brachial valve.

ÖPIKINA MINNESOTENSIS (N. H. Winchell)

Plate 245, D, figures 21-28

Strophomena minnesotensis N. H. WINCHELL, 9th Ann. Rep. Minnesota Geol. Nat. Hist. Surv., p. 120, 1881.

Öpikina minnesotensis (N. H. Winchell) SALMON, Journ. Paleont., vol. 16, No. 5, p. 592, pl. 87, figs. 5-11, 1942 (complete synonymy).

Types.—Hypotypes: 24705, 24708a,b, 45277a-c.

Horizon and locality.—Platteville formation (McGregor member) in Minnesota: At Minneapolis; on U. S. Highway 52, 2 to 3 miles north of Fountain, Goodhue County.

Same formation in Wisconsin: Bluff at Hudson, St. Croix County; Janesville, Rock County; Mineral Point, Iowa County; Bellville, Dane County; Pomeroy's Quarry, River Falls, Pierce County; quarry at the junction of Wisconsin Highways 130 and 23, north of Dodgeville, Iowa County; Rocktown, Ripon Center, quarry on Wisconsin Highway 81, 1 mile north of Ellenboro, Grant County; Beloit, Rock County.

Same formation in Illinois: 1½ miles northeast of Dixon, Dixon (15') Quadrangle.

Discussion.—This species is similar to *Ö. septata* internally and externally, but the Minnesota species is more convex and has a much larger muscle scar in the pedicle valve.

ÖPIKINA NASUTA Cooper, new species

Plate 242, C, figures 11-13a

Shell of about medium size for the genus, slightly wider than long and with the hinge about equal to the midwidth; cardinal extremities nearly a right angle; sides gently curved, subparallel; anterior margin narrowly rounded; surface costellate; visceral region with obscure concentric wrinkles.

Pedicle valve with uneven convexity, the posterior two-thirds nearly flat but the anterior third abruptly and sharply bent in the direction of the brachial valve. Anterior profile strongly domed. Angle of geniculation 115°; umbo narrowly swollen to form a short fold; lateral slopes precipitous; anterior slope long and steep; anterior third swollen and narrowed to give a nasute effect to the valve.

Muscle area equal in length to about one-third the valve length, deeply bilobed at the front.

Brachial valve nearly flat to gently convex in lateral profile; sides narrowly and abruptly bent toward the brachial valve. Interior with prominent, stout but short septa anterior to the adductor field; septa between adductors stout.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thick-ness | Height |
|--------------------------------------|--------|-----------------|----------|-------------|------------|--------|
| Holotype (pedicle valve) | 19.6 | ? | 21.3 | 19.8 | ? | 7.3 |
| Paratype (brachial valve 117821b) .. | ? | 15.6 | 18.2 | 19.4 | ? | ? |
| " (" " 117821a) .. | ? | 14.2 | 18.6 | 19.6 | ? | ? |

Types.—Holotype: 117821e; figured paratype: 117821a; unfigured paratypes: 117821b-d,f.

Horizon and locality.—Chatham Hill formation in Virginia: 1.2 miles S.31° E. of Sharon Springs, Burkes Garden (15') Quadrangle.

Discussion.—The species is different from all other described species except one. It is characterized by an unusually flat posterior region and a strongly and abruptly geniculated anterior, which produces a long trail in the pedicle valve. The only other species suggestive of this one is *Ö. ? dubia*, but that is smaller and has a shorter geniculated region. Interiors of the brachial valve have the important elements of *Öpikina*.

ÖPIKINA PARVULA Cooper, new species

Plate 244, A, figures 1-9

Small for the genus, subrectangular in outline, wider than long; hinge narrower than the midwidth; sides subparallel; anterior margin broadly rounded; 4 costellae in 1 mm. at the anterior margin; posterior margin with short, oblique wrinkles.

Pedicle valve geniculated anterior to the middle in lateral profile; angle of geniculation about 115°; anterior profile strongly domed; geniculation occurring at 6 to 8 mm. anterior to the beak; geniculated part narrowly rounded; visceral region gently convex in lateral profile; anterior slope convex and steep. Lateral slopes steep. Posterior margin nearly straight; beak small and slightly protuberant.

Brachial valve with visceral region gently concave; umbonal region concave, the concavity forming an indistinct sulcus to about the middle; sides moderately, and anterior strongly, deflected toward the brachial valve to surround the visceral concave region.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 11.7 | 10.8 | 13.5 | 12.7 | 2.7 | 4.8 |
| Paratype (117823b) | 10.2 | 9.2 | 11.2 | 10.2 | 2.4 | 4.2 |
| " (117822a) | 9.8 ? | 8.8 ? | 11.7 | 12.3 | 2.0 | 3.6 |

Types.—Holotype: 117823a; figured paratype: 117822a; unfigured paratypes: 117822b,c, 117823b,c.

Horizon and locality.—Benbolt formation in Virginia: 5 miles northwest of Wytheville, Wythe County; $\frac{1}{4}$ mile southeast of Green Valley Church, 3 miles southwest of Lebanon, Brumley (T.V.A. 205-SE) Quadrangle.

Discussion.—For comparison with *Ö. bellula* and *Ö. dorsatiformis* see those species.

ÖPIKINA ? PLANULATA Cooper, new species

Plate 247, A, figures 1-4

Shell large for the genus, subquadrate in outline, length slightly less than the width; hinge forming the widest part; sides oblique; anterior margin somewhat narrowly rounded; costellae on pedicle valve numbering 3 to the millimeter at the front margin, 2 large and 1 small; brachial valve with somewhat finer costellae, usually 4 to the millimeter of subequal costellae.

Pedicle valve gently convex in lateral profile with the anterior profile broadly convex; umbo narrowly swollen to form a short fold; umbonal slopes descending gently to the cardinal extremities; median region gently swollen; anterior slope gently convex but steeper than the longer lateral slopes. Muscle field not quite reaching the middle.

Brachial valve gently concave in the posterior region and reaching its deepest part anterior to the middle; cardinal extremities flattened. Sides gently deflected toward the brachial valve; anterior margin fairly strongly bent in the direction of the brachial valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype (pedicle valve) | 22.1 | ? | 26.9 | 32.2 | ? | 3.5 |
| Paratype (brachial valve 117824b) .. | ? | 28.8 | 32.3 | 35.5 | ? | ? |

Types.—Holotype: 117824a; figured paratypes: 117824b-d; unfigured paratypes: 117824e-g.

Horizon and locality.—Pierce formation in Tennessee: At old Pierce Mill site on Stone River at bridge on Tennessee Highway 10, just south of Walterhill, $7\frac{1}{2}$ miles north-northeast of Murfreesboro, Rutherford County.

Discussion.—This species is questionably referred to *Öpikina*. It has some features that suggest *Macrocoelia* such as the large size and low convexity, but the small muscle scar in the pedicle valve is not characteristic of *Macrocoelia*. A small brachial interior is more suggestive of *Öpikina*. If it belongs to that genus, it is the least convex of the species discussed herein. If it belongs to *Macrocoelia*, it is suggestive of *M. bella* but is differently shaped and not quite so convex.

ÖPIKINA PULCHELLA Cooper, new species

Plate 244, B, figures 10-16; plate 246, B, figures 3, 4

Shell small for the genus, longer than wide, and with the hinge forming the widest part. Sides gently rounded, oblique; anterior margin narrowly rounded to subnasute; cardinal extremities nearly a right angle. Costellate, 4 to 5 costellae in 1 mm. at the front margin.

Lateral profile unevenly convex, narrowly rounded at about the middle, the angle of geniculation about 95° ; anterior profile narrowly convex; visceral region gently swollen and gently convex in profile; anterior slope gently convex but long and steep; lateral slopes long and steep, about equal to the anterior slope; interarea moderately long. Interior with elongate diductors and large adjustor scars; pallial marks well developed.

Brachial valve gently concave in the visceral region; deepest just anterior to the middle; sides and anterior margin strongly and abruptly bent toward the brachial valve to surround the visceral region.

Measurements in mm.—Holotype, length 9.5, brachial length 8.6, midwidth 10.4, hinge width 10.5, thickness 4.2, height 6.0.

Types.—Holotype: 117825a; figured paratype: 117825b.

Horizon and locality.—Benbolt formation (base) in Virginia: 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Discussion.—This species is unlike all others herein described in its small size and strong convexity. It is much smaller than *Ö. dorsatiformis* or *Ö. parvula* which are both small species. The shell is thick and the pallial marks strongly impressed.

ÖPIKINA QUADRATA Cooper, new species

Plate 241, B, figures 9-13

Shell of about medium size, with the length and width about equal; sides gently rounded, subparallel; anterior margin somewhat narrowly rounded; hinge variable, generally less than the midwidth in the adult; costellae numbering about 3 of the stronger ones to 1 mm. at the front margin.

Pedicle valve fairly evenly and gently convex in lateral profile and with the maximum convexity just anterior to the middle; anterior profile broadly and gently convex, not domed; umbonal region somewhat broadly swollen and moderately elevated above the posterolateral regions; median and anterior region moderately swollen; anterior slope about equal to the lateral slopes but somewhat steeper. Muscle area large and not quite reaching the middle.

Brachial valve deepest in the midregion but not of great depth anywhere on the valve; posterior region gently concave and deepening toward the middle; margins moderately bent toward the brachial valve to form a gently sloping rim. Interior with septa not strongly developed and adductor ridges and margins thickened. Subperipheral rim moderately thickened.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | ? | 20.0 | 21.5 | 20.5 | ? | ? |
| Paratype (117826a) | ? | 19.3 | 20.3 | 21.7 | ? | ? |
| " (117826b) | 20.5 | ? | 23.4 ? | 20.6 | ? | 5.3 |
| " (117826c) | ? | 19.1 | 20.0 | 21.9 | ? | ? |
| " (117826d) | 20.0 | ? | 20.9 | 19.4 | ? | 4.3 |

Types.—Holotype: 117826e; figured paratypes: 117826b,d,f; unfigured paratypes: 117826a,c.

Horizon and locality.—Top of the Ridley formation in Tennessee: On east side of Marshall Knobs, 5 miles south of Murfreesboro, Murfreesboro (15') Quadrangle.

Discussion.—This species is characterized by low convexity and nearly square outline. It differs from *Ö. speciosa* in its lesser convexity and the flatness of the brachial valve. It approaches *Ö. subplanodorsata* but is even flatter than that species.

ÖPIKINA SEPTATA Salmon

Plate 239, B, figures 8-28

Öpikina septata SALMON, Journ. Paleont., vol. 16, No. 5, p. 591, pl. 87, figs. 1-4, 1942.

Types.—Holotype: 117829c; paratypes: 117829a,b; figured hypotypes: 117827a,b, 117828, 117830.

Horizon and locality.—Lebanon formation (upper half = *Doleroides* zone) in Tennessee: On U. S. Highway 41, $\frac{3}{4}$ mile south of Knox Branch, 9 miles southeast of Murfreesboro; U. S. Highway 70S, 0.8 mile west of Dry Branch of Cripple Creek; cut on U. S. Highway 241, 2.1 miles north of Bedford County line; U. S. Highway 41, $1\frac{1}{2}$ miles northwest of Mount Olivet, 10 miles southeast of Murfreesboro; Rutherford County. On U. S. Highway 70N opposite Fairview Service Station, $\frac{1}{2}$ mile west of Rome, Smith County; on U. S. Highway 70S, $\frac{3}{4}$ mile east of Readyville, Woodbury (15') Quadrangle; Columbia, Maury County; Lebanon, Wilson County.

Discussion.—This species is characterized by its wide hinge and low convexity. It is quite different from *Ö. transversa* of the Wardell formation of Rye Cove which is much more convex and often more transverse. *Öpikina septata* is suggestive of *Ö. minnesotensis*, but that species is differently shaped, less alate, and has a much larger muscle area in the pedicle valve.

ÖPIKINA SPECIOSA Cooper, new species

Plate 237, A, figures 1-19; plate 238, A, figures 1-7; plate 241, D, figures 20-28; plate 247, E, figures 14-16; plate 249, A, figures 1-9

Shell of about medium size for the genus; subrectangular in outline; wider than long and with the hinge usually forming the widest part; cardinal extremities subauriculate; sides slightly oblique; anterior margin narrowly rounded; costellae differentiated into strong and fine, numbering about 4 to the millimeter at the front margin; concentric fila strong. Concentric oblique wrinkles mark the posterior margin.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity located just anterior to the middle; posterior three-fifths gently convex in lateral profile; anterior two-fifths strongly bent at an angle varying from 100° to 120° toward the brachial valve; anterior slope rounded and steep; lateral slopes longer than the anterior one and much less steep. Interior with muscle

field occupying about half the interior, extending from the delthyrial cavity to the place of geniculation. Thin median septum prominent.

Brachial valve gently concave in the posterior three-fifths but with the lateral and anterior margins strongly bent in the direction of the brachial valve; greatest depth just anterior to the middle. Interior with septa subdued but well developed; cardinal process stout; subperipheral rim thick and beaded.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 23.1 | 20.9 | 26.6 | 30.0 | 5.6 | 9.9 |
| Paratype (117837a) | 20.8 | 19.1 | 21.6 | 21.9 | 5.2 | 9.5 |
| " (117837b) | 21.2 | 19.8 | 22.6 | ? | 4.0 | 7.8 |
| " (117836b) | 21.1 | 19.7 | 24.1 | 24.8 | 3.0 | 6.3 |
| " (117833e) | 21.5 | 19.7 | 23.3 | 26.8 | 4.8 | 8.8 |
| " (117833a) | 20.2 | 19.0 | 22.9 | 24.4 | 3.0 | 7.9 |
| " (117838a) | 21.7 | ? | 23.5 | 23.1 | ? | ? |
| " (117839d) | 20.0 | 18.7 | 23.0 | 24.4 | 5.0 ? | 7.7 |
| " (117839b) | 24.1 | 22.7 | 26.2 | 27.0 | 4.9 | 10.3 ? |

Types.—Holotype: 117835a; figured paratypes: 117831b, 117833a,c-e, 117834a,b,e, 117835b,d, 117836a, 117837a-c, 117838a, 117839b,e,f,h,i; 123287b; unfigured paratypes: 117831a, 117832a-f, 117833b, 117834c,d, 117835c,e,f, 117836b, 117838b, 117839a,c,d,g, 123287a.

Horizon and locality.—Ridley formation in Tennessee: 0.6 mile south of Chapel Hill Methodist Church on Tennessee Highway 28, 1 mile south of its junction with Tennessee Highway 8, Daus (T.V.A. 104-SW) Quadrangle.

Wardell formation and Wardell part of Dryden formation in Tennessee: North of the canyon of Gap Creek, Powell Valley, military coordinates 790250N, 2677730E, 1¼ miles west of Arthur, Cumberland Gap (T.V.A. 153-SW) Quadrangle; Jacksboro, Jacksboro (T.V.A. 136-SW) Quadrangle; road at the base of Cedar Ridge ¾ mile southeast of Litton, Sequatchie Valley, Pikeville Special (15') Quadrangle; Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; U. S. Highway 25E, ½ mile north of Indian Creek, Evans Ferry section, Howard Quarter (T.V.A. 162-NW) Quadrangle; on old Tennessee Highway 33, 0.3 mile southwest of Little Barren Church, Powder Springs (T.V.A. 154-SW) Quadrangle; Tennessee Highway 33, ½ mile west of the cemetery at the bend below Kecks Mill, Powder Springs (T.V.A. 154-SW) Quadrangle; 2 miles northeast and 1 mile west of old Tazewell, Tazewell (T.V.A. 154-NE) Quadrangle; back of Camp Loyston, Maynardville (30') Quadrangle.

Same formation in Virginia: In the north quarry on Station Creek, ¼ mile south of U. S. Highway 58, 2 miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle.

Ridley formation in Murfreesboro (15') Quadrangle, Tennessee: In the lower third of the formation on the east side of Marshall Knobs, 5 miles south of Murfreesboro; Bradleys Creek 1 mile east of Murfreesboro.

Pierce formation in Tennessee: Bradleys Creek, 1 mile east of Lascassas, Rutherford County.

"Lebanon" limestone=Ridley formation=Wardell formation in Georgia: In a quarry $1\frac{1}{2}$ miles south-southeast of Cove Church, Kensington (T.V.A. 206-SE) Quadrangle; on U. S. Highway 27, 1 mile north of Rock Spring, Nickajack Gap (T.V.A. 113-SW) Quadrangle.

Discussion.—This species is abundant and widespread in the Wardell formation in Virginia and Tennessee. It resembles *Ö. transitionalis* Okulitch, but significant differences between the two species can be detected. *Öpikina speciosa* as defined and identified herein is a variable species and may ultimately be further split. The specimens from the Ridley formation of the central basin of Tennessee appear to be somewhat narrower than those from the Wardell formation along the Cumberland Front and in Sequatchie Valley. However, length-width index of these narrow forms differs 0.07 from the broadest specimens.

Öpikina speciosa is suggestive of *Ö. transitionalis*, *Ö. inquassa*, and *Ö. formosa*. Comparison with the last species is made above. From *Ö. inquassa* the Appalachian species differs in having its geniculation farther anterior to the beak than in the Minnesota species. Thus the maximum convexity is farther anterior than in the Minnesota species. The anterior trail of *Ö. speciosa* is more swollen and steeper than that of *Ö. inquassa*. According to Salmon (1942, p. 596) *Ö. transitionalis* possesses "sharply projecting ears and a sinuous lateral margin." These are not features of *Ö. speciosa*. Dr. Salmon states further that the geniculation in *Ö. inquassa* occurs farther toward the anterior than in *Ö. transitionalis*. This feature makes comparison with *Ö. speciosa* still more remote because its geniculation takes place farther anterior than it does in *Ö. inquassa*.

Öpikina speciosa is more strongly geniculated and farther from the beak than in *Ö. lirata*. The Oklahoma *Öpikinas* are all different from *Ö. speciosa*.

ÖPIKINA SUBPLANODORSATA Cooper, new species

Plate 241, C, figures 14-19

Shell of about medium size for the genus, subquadrate; slightly wider than long, the hinge usually narrower than the width at the middle; sides gently rounded, subparallel; anterior margin narrowly rounded; cardinal extremities obtuse. Costellae fine and thin, 3 or 4 to a millimeter at the front margin.

Pedicle valve unevenly convex in lateral profile, the posterior three-fifths nearly flat except near the beak where it is somewhat swollen; anterior two-fifths gently rounded but forming a fairly steep anterior slope bent about 115° from the posterior part. Geniculation prominent in the adult; sides with moderately steep slopes.

Brachial valve gently and evenly concave throughout its length; maximum concavity located at the middle or slightly anterior to it. Sides and anterior margins bent only slightly toward the brachial valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 22.7 | 21.0 | 24.6 | 20.4 | 6.3 | 8.2 |
| Paratype (117840c) | 21.8 | 19.8 | 26.0 | 22.0 | 5.6 | 7.4 |

Types.—Holotype: 117840a; figured paratype: 117840b; unfigured paratype: 117840c.

Horizon and locality.—Wardell formation in Tennessee: On the north side of the road 1.1 miles northeast of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; 2 miles northeast of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle.

Davis' store, 5 miles west of Eidson, Hawkins County; military coordinates 719410N, 2746920E, hill west of west fork of center branch of Notchy Creek, Avondale (T.V.A. 162-SW) Quadrangle.

Same formation in Virginia: $\frac{1}{4}$ mile west of the Danlboone Siding on U. S. Highway 58, Gate City (T.V.A. 188-NE) Quadrangle.

Discussion.—This species is similar to *Ö. speciosa* and to *Ö. inquassa* but differs from both of them in having the brachial valve gently concave.

ÖPIKINA TRANSITIONALIS (Okulitch)

Rafinesquina transitionalis OKULITCH, Canadian Field-Nat., vol. 49, No. 6, p. 97, pl. 1, figs. 3, 4, 1935.

Öpikina transitionalis (Okulitch) SALMON, Journ. Paleont., vol. 16, No. 5, p. 595, pl. 87, figs. 15-18, 1942.—WILSON, Geol. Surv. Canada, Bull. 8, p. 93, 1946 (specimen figured rejected by Salmon and placed in *Ö. wagneri* (Okulitch)).

Types.—Holotype: Peter Redpath Mus., McGill Univ., Montreal.

Horizon and locality.—Lowville and Leray formations in Quebec: At Pointe Claire. "One of the most common species of *Öpikina* in North America" according to Salmon (1942, p. 596).

Discussion.—This species has been widely identified by Salmon and others from Middle Ordovician rocks, but the species could not be identified in any of the collections herein described. It is suggested that its affinities are with the more northern areas of outcrop of Black River-Early Trenton strata.

ÖPIKINA TRANSVERSA Cooper, new species

Plate 244, C, figures 17-32

Shell small for the genus, wider than long and with the hinge usually forming the widest part; cardinal extremities subauriculate; sides gently rounded and oblique; anterior margin broadly rounded; finely costellate, 2 or 3 of the larger costellae occupying 1 mm. at the front margin. Posterior margin with oblique wrinkles.

Pedicle valve strongly but unevenly convex in lateral profile, the maximum convexity located at or just anterior to the middle; anterior broadly and usually strongly domed; visceral region gently to moderately convex; geniculated portion somewhat narrowly rounded about half the surface length of the pedicle valve to the beak. Anterior slope gently convex, steep and longer than the lateral slopes which are also steep. Interarea short.

Brachial valve with visceral region gently concave and surrounded by the strongly curved lateral and anterior margins. Brachial valve deepest just anterior to the middle.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|--------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 16.1 | 14.4 | 20.5 | 20.2+ | 3.9 | 7.4 |
| Paratype (117844b) | 16.5 | 14.8 | 21.0 | 20.0 | 4.2 | 6.9 |
| " (117844d) | 13.0 | 12.0 | 16.6 | 16.8 | 3.2 | 5.0 |
| " (117843a) | 15.8 | 14.6 | 19.1 | 20.2 | 2.8 | 5.1 |
| " (117843b) | 14.5 | 13.3 | 18.0 | 17.3 | 2.6 | 5.0 |
| " (117843c) | 13.8 | 12.7 | 17.7 | ? | 3.0 | 5.6 |
| " (117846a) | 11.8 | 11.2 | 16.7 | 20.4 | 1.6 | 2.5 |
| " (117846c) | 14.1 | 13.1 | 18.3 | 17.5 | 3.0 | 5.8 |
| " (117845a) | 19.9 | 18.3 | 27.2 | 23.7 | 4.4 | 10.0 |
| " (117842) | 17.4 | 16.4 | 22.5 | 26.1 | 2.4 | 5.7 |

Types.—Holotype: 117844a; figured paratypes: 98226a,b, 117843d, 117846a-d, 123276a; unfigured paratypes: 98226c-h, 117842, 117843a-c, 117844b-d, 117845a-f, 117846e, 123276b.

Horizon and locality.—Wardell formation and Wardell part of Dryden formation in Tennessee: Lloyd Carter's barn, 0.8 mile by road northeast of Rye Cove School; second road cut west of L. McDavid's house, 1 mile west of Rye Cove; Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This is a variable species ranging from extremely transverse shells to ones that are nearly square in outline. This species is smaller, wider, and more convex than *Ö. speciosa* and *formosa*. It is larger and more convex than *Ö. parvula* and is shaped and ornamented differently from *Ö. bellula*. Besides being very differently shaped, it is more convex and also more deeply concave than *Ö. minnesotensis* to which it has mistakenly been referred. The shell geniculates nearer the beak than in *Ö. varia*.

ÖPIKINA VARIA Cooper, new species

Plate 240, A, figures 1-7

Rafinesquina aff. *minnesotensis* BUTTS (not Winchell), Alabama Geol. Surv., Special Rep. 14, p. 126, pl. 31, figs. 23, 24, 1926.

Shell small for the genus, subquadrate to subrectangular in outline, slightly wider than long; sides gently rounded, subparallel; anterior margin broadly rounded. Hinge generally equal to or less than the width at the middle. Costellae well differentiated, 2 of the larger size in 1 mm. at the front margin. Larger costellae separated by 2 to 4 of the finer ones.

Pedicle valve unevenly convex in lateral profile, with the maximum convexity anterior to the middle; anterior profile moderately domed; geniculation occurring about 11 mm. anterior to the beak; angle of geniculation 115°; visceral region varying in lateral profile from nearly flat to moderately convex; anterior slope gently convex, short and steep; sides with short and steep slopes; interior with muscle field to about the middle of the valve.

Brachial valve gently concave in the visceral region which extends for about $\frac{3}{4}$ the length; deepest part anterior to middle; sides and anterior margin narrow and abruptly bent in the direction of the brachial valve.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|------------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 15.1 | 13.6 | 17.2 | 18.0 | 4.5 | 6.9 |
| Paratype (71350a)..... | 15.1 | ? | 17.3 | 16.6 | ? | 5.0 |

Types.—Holotype: 117848a; figured paratypes: 71350a,b, 117847a,c, 117848b; unfigured paratypes: 117847b, 117848c-e.

Horizon and locality.—Carters formation in Alabama: In the *Oxoplectia* beds from the quarry 0.3 mile north of Gate City, Leeds (15') Quadrangle; Cedar Mountain, 2 miles southwest of Argo, Birmingham (30') Quadrangle.

Dryden formation in Virginia: In the vicinity of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Dryden formation in Tennessee: On the Lone Mountain to Tazewell road, 1½ miles northeast of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle; on Little Sycamore Creek, ½ mile northeast of the west edge of the Howard Quarter (T.V.A. 162-NW) Quadrangle.

Discussion.—This is a species of moderate size which is variable and without any one mark of distinction. It is about the size of *Ö. bellula* but differs from that species in convexity and character of ornamentation. It differs from *Ö. transversa* in being only moderately extended along the hinge and in having its convexity farther anterior than that of *Ö. transversa* which has its convexity near the middle. *Öpikina varia* differs from *Ö. minnesotensis* in having its maximum convexity posterior to that of the Minnesota shell.

ÖPIKINA WAGNERI (Okulitch)

Rafnesquina wagneri OKULITCH, Canadian Field Nat., vol. 49, No. 6, p. 98, pl. 1, fig. 5, 1935.

Öpikina wagneri (Okulitch) SALMON, Journ. Paleont., vol. 16, No. 5, p. 596, pl. 87, figs. 19-27, 1942.—WILSON, Geol. Surv. Canada, Bull. 8, p. 94, pl. 8, figs. 14a, b, 1946.

R. transitionalis (Okulitch) part, idem, p. 97, pl. 1, fig. 4 (not fig. 3), 1935.

R. williamsi OKULITCH, idem, p. 98, pl. 1, fig. 6, 1935.

Type.—Holotype: Peter Redpath Mus., McGill Univ., Montreal.

Horizon and locality.—Leray=Chaumont formation in Quebec: At St. Vincent de Paul.

ÖPIKINA in Canada

Dr. Alice Wilson in 1944 described many species of *Öpikina* from the Leray-Rockland beds of the Ottawa St. Lawrence Lowland. These species appeared first in Transactions of the Royal Society of Canada, ser. 3, vol. 38, sec. 4, 1944, and later in Geological Survey of Canada, Bull. 8, 1946. The species are listed below in alphabetical order. The first set of figures are the page and plate references to the Royal Society of Canada publication, and the second set of figures refer to the Geological Survey of Canada paper.

Öpikina ampla Wilson, p. 190, text fig. 10, No. 12, pl. 2, fig. 26.

p. 89, text fig. 10, No. 12, pl. 6, fig. 29.

Ö. gloucesterensis Wilson, p. 191, text fig. 10, No. 4, pl. 2, fig. 19.

p. 89, text fig. 10, No. 4, pl. 6, fig. 20.

- Ö. hemispherica* Wilson, p. 192, text fig. 10, No. 11, pl. 2, fig. 20.
p. 90, text fig. 10, No. 11, pl. 6, fig. 21.
- Ö. ovalis* Wilson, p. 192.
p. 90, pl. 8, fig. 20, 21.
- Ö. platys* Wilson, p. 193, text fig. 10, No. 3, pl. 2, figs. 21, 21b.
p. 91, text fig. 10, No. 3, pl. 6, figs. 22, 23.
- Ö. rugosa* (Wilson), Geol. Surv. Canada, Bull. 33, p. 51, pl. 3, figs. 8, 9, 1921.
p. 194, text fig. 10, No. 1.
p. 91, text fig. 10, No. 1, pl. 8, figs. 22, 23.
- Ö. (?) rugosa avita* (Wilson), Canadian Field Nat., vol. 46, No. 6, 1932.
p. 138, pl. 2, figs. 6-13.
p. 195, text fig. 10, No. 2.
p. 91, text fig. 10, No. 2, pl. 8, figs. 15-19.
- Ö. septata borealis* Wilson, p. 195, text fig. 10, No. 6, pl. 2, fig. 15.
p. 92, text fig. 10, No. 6, pl. 6, fig. 15.
- Ö. sinclairi* Wilson, p. 196, text fig. 10, No. 9, pl. 2, figs. 18a, b.
p. 92, text fig. 10, No. 9, pl. 6, figs. 18, 19.
- Ö. subtriangularis* Wilson, p. 196, text fig. 10, No. 5, pl. 2, fig. 22.
p. 92, text fig. 10, No. 5, pl. 6, fig. 24.
- Ö. tumida* Wilson, p. 197, text fig. 10, No. 10, pl. 2, fig. 16.
p. 93, text fig. 10, No. 10, pl. 6, fig. 16.
- Ö. wagneri robusta* Wilson, p. 198, text fig. 10, No. 8, pl. 2, figs. 25a, 25b.
p. 94, text fig. 10, No. 8, pl. 6, figs. 27, 28.

ÖPIKINA sp. 1

Plate 242, A, figures 1-5

This is a species characterized by low convexity and not strongly pronounced geniculation. It somewhat resembles *Ö. subplanodorsata* but is more concave. It is also suggestive of *Ö. varia*, but the place of geniculation is farther from the beak and the ornamentation is different.

Measurements in mm.—117849, length 14.5, brachial length 13.4, midwidth 15.1, hinge width 15.9, thickness 3.3, height 4.8.

Figured specimen.—117849.

Horizon and locality.—Benbolt formation in Virginia: On the east bank of a sinkhole south of Lakeview Church on Virginia Highway 71, southwest quarter of east-central subquad., Moll Creek (T.V.A. 196-SE) Quadrangle; 1½ miles southwest of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

ÖPIKINA sp. 2

This is a small species elongate or subquadrate, of modest height and depth and with geniculation occurring at 10 to 13 mm. anterior to the beak. It is suggestive of *Ö. parvula*, but the Oklahoma shell is not so deep and is somewhat differently proportioned. This Oklahoma species is smaller than *Ö. varia* and differently proportioned.

Measurements in mm.—117850, length 16.5, brachial length 15.6, midwidth 16.2, hinge width 13.8, thickness 3.0, height 5.1.

Described specimen.—117850.

Horizon and locality.—Bromide formation (Pooleville member-zone 2) in Oklahoma: West of Nebo store, sec. 22, T. 2 S., R. 3 E., Murray County.

ÖPIKINA sp. 3

This is a species of medium size having fairly low convexity, prominent beak, and narrowly swollen umbo. The posterior half is characterized by costellae alternating in size, but at the anterior the costellae are nearly equal and number 4 to the millimeter. The specimen is not like any other in the collection but is not complete enough for specific designation.

Measurements in mm.—117851, length 18.0, midwidth 21.5, hinge width 20.3?, height 4.5?.

Described specimen.—117851.

Horizon and locality.—Edinburg formation (*Cyrtototella* zone) in Virginia: In the railroad cut about $\frac{1}{8}$ mile east of Strasburg Junction, Strasburg (15') Quadrangle.

ÖPIKINA sp. 4

A single specimen of fairly large size for the genus, having a somewhat nasute front and considerable height, is so poorly preserved that specific description is inadvisable. The specimen is significant, however, because of its occurrence in the Little Oak limestone. It is suggestive of some from the Ridley of West Tennessee.

Measurements in mm.—123295, length 22.8, brachial length 19.7, midwidth 23.0?, thickness 4.1, height 10.4.

Described specimen.—123295.

Horizon and locality.—Little Oak formation in Alabama: At the junction of the Bailey Gap and Cahaba Valley roads, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle.

ÖPIKINA sp. 5

Plate 268, E, figures 16-24

This is a variable or possibly a mixed species that occurs abundantly in the Whistle Creek formation of Catawba Valley. It is moderately large, fairly strongly convex, and with the convexity just anterior to the middle. The brachial valve is deeply concave. The muscle field of the pedicle valve is nearly circular and of moderate size. The species is quite unlike either of the Arline species and appears remarkably advanced for the earliest *Öpikina*.

Measurements in mm.—123292a, length 18.7, brachial length 17.1, midwidth 22.5, hinge width ?, thickness 3.7.

Figured specimens.—123292a-d.

Horizon and locality.—Ellett formation (75 feet above the Knox dolomite) in Virginia: On Indian Run, $\frac{3}{4}$ mile northwest of Lusters Gate, Blacksburg (15') Quadrangle.

Discussion.—Unfortunately, the material collected is not good enough on

which to establish a species, and the interior of the brachial valve is unknown. This is the earliest *Öpikina* known.

Genus **STROPHOMENA** Blainville, 1825

Strophomena BLAINVILLE, Man. Malacol., vol. 1, p. 513, 1825.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 245, 1892.

Öpikina WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 38, sec. 4, p. 199, 1944; Geol. Surv. Canada, Bull. 8, p. 95, 1946.

Strophomena is an abundant brachiopod throughout rocks that are here assigned to the Wilderness and Trenton stages. This name is applied to convex-concave brachiopods having moderately large muscle fields in the pedicle valve which are partially surrounded by a thickening extending anteriorly from the dental ridge. Inside the brachial valve the cardinalia are generally small and delicate, the median ridge short, and pallial marks not well impressed. Comparison with the genotype, *Strophomena planumbona* (Hall), shows essential agreement in most of the important details. Nevertheless, a fair variety of forms has been brought together here under the name *Strophomena*. Ultimately, some splitting of groups is likely, but the collections available in this study are too few to make any progress along these lines possible.

The National Collection is not well provided with specimens of *Strophomena* except from a few localities. The collections from the Arbuckles are excellent, but those from the Appalachians are good from only a few places. Wardell and Ridley specimens are numerous, but only a few of quality have been taken from the Witten or higher beds. Good material from the Central Basin of Tennessee was studied, but the collections from New York and Ontario are meager indeed.

The only regions in which a notable number of species of *Strophomena* have been described are the region about Ottawa, Ontario, and the Plattin area of eastern Missouri. The Ontario Black River and Trenton faunas were described by Dr. Alice E. Wilson. Many species of *Strophomena* are described, and two genera have been split off from it. In general, the species are not adequately illustrated, and the original specimens show evidence of exfoliation. This is not ideal material for constructing new species. It has therefore not been possible to identify any of the Wilson species outside of New York and Ontario.

Similar remarks may be applied to Fenton's descriptions of species of *Strophomena* from the Plattin of the Ste. Genevieve County area in eastern Missouri. The material illustrated by Fenton is good but the illustrations feature chiefly interiors of pedicle valves and occasional other views. No profiles are given, and great reliance is put on the interior of the pedicle valve. Fenton relegates a position of unimportance in the classification of species to the shape of the shell, wrinkling of the cardinal extremities, the costellation, and thickness. The writer believes that even the muscle scars of the pedicle valve of this genus are not reliable because they are so variable. Total available features must be taken into account in defining a species of this genus. Few of Fenton's species are recognizable in the Appalachians.

Black River and Trenton *Strophomena* must some day be studied as a whole

to make the group useful, but the study will require enormous collections which are not now available.

STROPHOMENA ANOMALA Cooper, new species

Plate 264, A, figures 1-15

Shell small for the genus, wider than long; subrectangular in outline; hinge equal to or less than the midwidth; sides gently rounded; anterior margin broadly rounded. Surface costellate, costellae of unequal size, intercalated in several generations and numbering 3 to the millimeter at the front margin.

Pedicle valve unevenly convex in lateral profile, the posterior half gently convex but the anterior half gently concave. Umbonal region narrowly swollen and forming a prominent narrow fold to about the valve middle or shortly beyond; flanks bounding fold forming long, flat to slightly concave slopes to the lateral margins; anterior third gently concave to flat; interarea long; pseudodeltidium prominent and swollen.

Brachial valve very gently convex in lateral and anterior profiles; umbo and median region marked by a shallow and narrow sulcus which disappears in the slight swelling to form the flattened anterior third; flanks bounding sulcus slightly swollen; posterolateral slopes gentle; cardinal extremities flattened and deflected slightly in the direction of the brachial valve.

Pedicle interior with muscle area nearly equal in length and width, but the anterior ends of the diductor scars elongated; dental ridges thick but not extended anteriorly around the adjustor-diductor scars. Brachial valve with small cardinal process but median ridge moderately long and stout.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-----------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 12.4 | 11.2 | 17.6 | 17.6 | 2.8 |
| Paratype (117701d) .. | 11.3 | 10.5 | 15.1 | 13.7 | 2.0 |

Types.—Holotype: 117700a; figured paratypes: 117701a,c,d; unfigured paratypes: 117700b, 117701b.

Horizon and locality.—Benbolt formation (base) in Virginia: 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Discussion.—This is a rare species known only from the Benbolt formation. It is characterized by fairly strong costellae, a strong median fold in the posterior half of the pedicle valve, and nearly even depth of both valves. The species suggests *Pionomena* but is actually resupinate although not strongly so. This latter feature will distinguish it from the other members of the genus described herein. *Strophomena* ? *emaciata* Winchell and Schuchert from Minnesota is still more biconvex and differently ornamented, so that little confusion will result between these two.

STROPHOMENA AUBURNENSIS Fenton

Plate 257, A, figures 1, 2; plate 263, C, figures 17-22

Strophomena auburnensis FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 148, pl. 9, figs. 1-3, 1928.

This species is a large one characterized by important exterior and interior details. The pedicle valve is completely concave except for the umbonal region which is slightly swollen or flat. The brachial valve is flattened in the posterior third when viewed in lateral profile, but the anterior two-thirds is fairly strongly convex. The pseudodeltidium is subcarinate like that of *S. crassicostellata* Cooper. The surface is marked by costellae of unequal size, strong costellae setting off groups of finer ones, as many as 5 of the finer ones in a group.

Inside the pedicle valve the muscle area is quite distinctive. Its length and width are about equal, and the sides are nearly straight, so that the field is like a small square with one angle in the delthyrial cavity, the two lateral ones narrowly rounded and the fourth directed anteriorly. Inside the brachial valve the brachiphores are rudimentary and enclosed in a small cup of adventitious shell; the cardinal process is delicate and the median ridge short.

Measurements in mm.—

| | | Length | Brachial length | Midwidth | Hinge width | Thickness |
|----------|----------------|--------|-----------------|----------|-------------|-----------|
| Hypotype | (117704a)..... | 27.3 ? | 25.6 ? | 36.0 | 35.6 | ? |
| " | (117704b)..... | 25.1 | ? | 32.8 | 34.9 | ? |
| " | (117702)..... | 35.8 | 34.7 | 45.0 | 47.6 | 7.8 |

Types.—Figured hypotypes: 117702, 117704a,b.

Horizon and locality.—Auburn chert in Missouri: $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle. Platteville formation: On Wisconsin Highway 81, 2 miles northwest of Platteville, Mineral Point (30') Quadrangle; 0.7 mile northeast of Dickeyville on Wisconsin Highway 151, Grant County.

Decorah formation (Guttenburg member) in Wisconsin: 0 to 8 feet above 8-inch blue clay on top of Platteville, Wisconsin Highway 81, 0.1 mile south of the Little Platte River, 2 miles northwest of Platteville, Mineral Point (30') Quadrangle.

Decorah formation (Spechts Ferry member—Glass Rock) in Illinois: $1\frac{1}{2}$ miles northeast of Dixon, Dixon (15') Quadrangle.

Discussion.—This species is characterized by large size and strong differentiation of its costae. It is a large and striking species and evidently at times has been confused with *S. filitexta* Hall.

STROPHOMENA AUBURNENSIS IMPRESSA Raasch*Strophomena auburnensis impressa* Raasch, in SHROCK and RAASCH, Amer. Midland Nat., vol. 18, No. 4, pp. 549, 592, pl. 4, figs. 6, 8, 1937.

Horizon and locality.—Platteville formation (upper Buff) in Wisconsin: At Beloit, Rock County; 3 miles south of New Glarus, Green County.

STROPHOMENA AUBURNENSIS NASUTA Cooper, new subspecies

Plate 257, B, figures 3-12

Strophomena incurvata FOERSTE (not Shepard), Bull. Sci. Lab., Denison Univ., vol. 17, p. 24, pl. 11, fig. 7, 1912.—BUTTS (not Shepard), Alabama Geol. Surv., Special Rep. 14, pl. 31, figs. 25-27; pl. 33, figs. 3, 4, 1926.

Shell large for the genus, subrectangular in outline; hinge usually forming the greatest width; sides nearly straight; anterior margin strongly rounded and generally somewhat nasute. Costellae unequal in size, 1 or 2 fine ones alternating with stronger ones, and 13 to 16 costellae occupying 5 mm. at the front margin.

Pedicle valve deeply concave in lateral profile and with the maximum concavity in the median region; umbonal region marked by a low and narrow fold that disappears at about one-third the length from the beak; posterior third gently concave, median third deeply concave and anterior third less concave than the preceding. Sides and anterior strongly reflected toward the pedicle valve. Cardinal extremities more or less auriculate, deflected sharply toward the brachial valve; interarea moderately long, strongly apsacline.

Brachial valve unevenly convex in lateral profile, the posterior third flattened but the anterior two-thirds strongly convex; anterior profile strongly and broadly convex; umbo marked by a fairly wide but shallow sulcus that extends nearly to the valve middle; posterior third flattened; anterior two-thirds strongly swollen and with steep lateral and anterior slopes. Posterolateral slopes long but only moderately steep; cardinal extremities strongly deflected toward the brachial valve.

Interior of pedicle valve with large subcircular to quadrate muscle scar, the anterior end of which reaches to about the valve middle; teeth and dental ridges strong; sides of muscle field with a thick and strongly elevated rim reaching nearly to the front of the scar. Subperipheral rim thick and beaded by numerous pallial distributaries. Brachial interior with short, stout cardinal process and delicate socket cups. Median ridge short.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 29.4 | 28.6 | 37.0 | 35.2 | 5.8 |
| Paratype (45507b) | 26.5 | ? | 28.3 | 31.6 | ? |
| “ (87091) | 32.0 | ? | 36.4 | 40.7 | ? |

Types.—Holotype: 45507a; figured paratypes: 45507b, 87091, figured hypotype: 117703a; unfigured paratypes: 45507c,d.

Horizon and locality.—Tyrone formation in Kentucky: At High Bridge, Harrodsburg (30') Quadrangle.

Carters formation in Tennessee: On the north side of U. S. Highway 70S, 0.8 mile east of Readyville, Rutherford County; McKnights Branch, 2 miles west of Willow Swamp School, Woodbury (15') Quadrangle; 1 mile east of Mount Carmel Church, same quadrangle; road crossing Watson Branch, ½ mile southwest of Conico Church, Franklin (15') Quadrangle; on U. S. High-

way 70N, just east of Round Lick Creek, Rome, Smith County; F. B. Cooper farm 2 miles southeast of Pikeville, Pikeville Special (15') Quadrangle; Auburn, Cannon County.

Carters formation in Alabama: Quarry $\frac{1}{2}$ mile northeast of Gate City, Leeds (15') Quadrangle; ? Birmingham, Birmingham (30') Quadrangle.

Discussion.—This subspecies is distinguished from other members of the species by the narrowed and nasute front. This is especially seen in the pedicle valves.

STROPHOMENA BASILICA Cooper, new species

Plate 258, A, figures 1-17

Shell of about average size for the genus, wider than long; subrectangular in outline; hinge equal to the midwidth or forming the greatest shell width; sides nearly straight but generally indented more or less strongly just anterior to the cardinal extremities; anterior margin strongly rounded; cardinal extremities varying from nearly a right angle to auriculate. Surface finely costellated, the costellae of 2 sizes, 1 to 3 of the finer ones alternating with the stronger ones; 18 costellae may be counted in the space of 5 mm. at the front, the figure including 5 of the stronger costellae.

Pedicle valve gently concave in lateral profile; umbonal region slightly convex, the convexity continued anteriorly for a short distance only; cardinal extremities flattened and deflected slightly toward the brachial valve; greatest concavity in the median region with the sides gently deflected toward the pedicle valve. Pseudodeltidium long, subcarinate; foramen minute; interarea moderately long.

Brachial valve unevenly convex in lateral profile, the posterior third flat and the anterior two-thirds moderately convex; anterior profile broadly and moderately convex. Posterior third flattened but with umbo concave, the concavity extended anteriorly nearly to the middle as a shallow and narrow sulcus; median half fairly strongly swollen; anterior slope convex, long, and steep. Lateral slopes shorter than the anterior one and moderately steep.

Interior of pedicle valve with variably shaped muscle field ranging from nearly circular to elongate oval; teeth small; dental ridges slender, flaring; ridges surrounding sides of muscle field low and not elevated anterior to the middle of the field. Interior of brachial valve with brachiophores nearly obsolete; sockets formed by short, delicate cups; cardinal process small and delicate. Median ridge low but long, extending for about a third the length.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 27.8 | 26.5 | 34.5 | 32.6 | 4.0 |
| Paratype (117705b)..... | ? | 26.1 | 32.0 | 31.1 | ? |
| “ (117705c)..... | 22.7 | ? | 26.9 | 26.5 | ? |
| “ (117705d)..... | ? | 22.0 | 25.8 | 26.7 | ? |
| “ (117705g)..... | 24.2 | 22.1 | 26.2 | 26.7 | 3.6 |

Types.—Holotype: 117705a; figured paratypes: 117705b-e,g,h, unfigured paratype: 117705f.

Horizon and locality.—Ridley formation in Tennessee: In the lower third of

the formation in Marshall Knobs, 5 miles south of Murfreesboro, Murfreesboro (15') Quadrangle.

Discussion.—This species is characterized by moderate convexity and concavity, thin body cavity, long interarea, well-rounded muscle area and fine, well-differentiated costellae. It differs from *S. medialis* in the finer ornamentation and more convex valves. It differs from *S. grandimusclosa* in the form and less thickening of the muscle area, the more rectangular cardinal extremities, differentiated ornamentation, and greater convexity. *Strophomena musclosa* from the Decorah shale is more convex and has a wider muscle field in the pedicle valve. The form and outline of *S. costellata* are similar, but the ornamentation of that species consists of costellae less differentiated in size than in the Ridley species.

STROPHOMENA BASILICOIDEA Cooper, new species

Plate 256, A, figures 1-5

Shell large, subrectangular in outline; hinge forming the greatest width; sides nearly straight but indented gently anterior to the cardinal extremities. Anterior margin broadly rounded. Costellae rounded, subequal, somewhat distant and alternating in size, about 13 to 15 in 5 mm. at the front margin.

Pedicle valve moderately concave in lateral profile; maximum concavity in the median third; umbo narrowly convex and with a short fold; umbo-lateral areas gently concave; median third deeply concave but anterior third more gently concave; interarea fairly long; pseudodeltidium narrowly convex, subcarinate.

Brachial valve evenly and strongly convex in lateral profile; broadly and moderately convex in anterior profile; maximum convexity at about the middle; posterior third somewhat flattened. Umbo marked by a short, narrow, shallow sulcus. Median region swollen; anterior slope convex, moderately long and steep; lateral slopes moderately long and steep. Interior with delicate cardinalia.

Measurements in mm.—Holotype, length, 25.6, brachial length 23.9, midwidth 31.0, hinge width ?, thickness 3.8.

Type.—Holotype: 117706.

Horizon and locality.—Peery formation in Virginia: On U. S. Highway 19, 400 feet west of the junction with Virginia Highway 650, Wittens Mills, Burkes Garden (15') Quadrangle.

Discussion.—This species is somewhat like *S. basilica* but differs in more closely crowded, stronger costellae and in having a more uniformly inflated brachial valve and a somewhat more concave pedicle valve.

STROPHOMENA BELLILINEATA Cooper, new species

Plate 262, A, figures 1-7

Shell large, slightly wider than long; subquadrate in outline; cardinal extremities slightly alate; sides nearly straight except for a gentle indentation just anterior to the cardinal extremities; anterior margin broadly rounded. Surface beautifully sculptured and consisting of strong costellae setting off groups of 10 to 12 finer ones; 4 of the stronger costellae appear in a space of 10 mm. at the anterior margin of a specimen 26 mm. long.

Pedicle valve very gently concave in lateral profile, with the maximum concavity near the valve middle; umbo narrowly and gently swollen to form a distinct but low fold extending anteriorly for a distance of about 8 mm. Median region very gently concave; lateral and anterior regions gently and broadly bent toward the pedicle valve. Interarea short, pseudodeltidium moderately convex; interior with elongate to subcircular muscle field; rim surrounding muscles moderately thickened. Old specimens with a moderately thick subperipheral rim.

Brachial valve fairly evenly but gently convex in lateral profile; anterior profile broadly convex; umbo concave, the concavity continued anteriorly as a short, narrow sulcus for about 8 mm. Median region gently swollen; lateral areas with long and gentle slopes. Cardinalia delicate for such a large shell; cardinal process small; median ridge low and short; sockets formed by narrow cuplike plates.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype (pedicle valve) | 33.5 | ? | 43.3 | 51.6 ? | ? |
| Paratype (brachial valve 117707b).... | ? | 27.0 | 35.7 | 38.7 ? | 2.4 ? |
| " (" " 123283)..... | ? | 35.9 | 46.8 | 46.8 | ? |

Types.—Holotype: 117707a; figured paratypes: 117707b,c, 123283; unfigured paratypes: 117707d-f.

Horizon and locality.—Oranda formation in Broadway (15') Quadrangle in Virginia: 0.6 mile west of Linville Station; on Virginia Highway 777 just west of its junction with Highway 617, $\frac{1}{4}$ mile north of Green Mount Church.

Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia Highway 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is characterized by its large size and strongly differentiated ornamentation. It has about the size of large specimens of *S. auburnensis* but is readily distinguished from that species by the concavity of the pedicle valve and the low convexity of the brachial valve.

STROPHOMENA BILLINGSI Winchell and Schuchert

Strophomena recta BILLINGS (not Conrad), Geol. Surv. Canada, Paleozoic fossils, vol. 1, p. 130, fig. 108 (adv. sheets, 1862), 1865.

S. billingsi WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, fig. 32, 1895.—WILSON, Geol. Surv. Canada, Bull. 8, p. 101, pl. 11, figs. 14a, b, 1946.

The type specimen is lost.

Horizon and locality.—Leray (Chaumont)—Rockland in Ontario, Canada.

STROPHOMENA CANADENSIS Wilson

Plate 248, A, figure 1

Strophomena canadensis WILSON, Geol. Surv. Canada, Bull. 33, p. 50, pl. 3, fig. 7, 1921.

Type.—Holotype: G.S.C. 6220.

Horizon and locality.—Pamelia formation, 22 miles west of Ottawa, Ontario, at MacLaren Landing.

STROPHOMENA CONRADI Hall and Clarke

Strophomena conradi HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 344, pl. 9, A, fig. 3, 1892.

Horizon and locality.—Jacksonburg formation in New Jersey: At Jacksonburg.

STROPHOMENA COSTELLATA Cooper, new species

Plate 255, A, figures 1-19

Shell of about average size for the genus, wider than long; hinge forming widest part; cardinal extremities subalate, deflected toward the brachial valve. Lateral margins nearly straight or slightly oblique; front margin broadly rounded. Surface marked by fine costellae which are of nearly equal size at the posterior, but between each pair of the primary costellae another finer one is intercalated for about 4 generations. Costellae increasing in size anteriorly, the primary set maintaining its advantage and appearing as the larger of the costellae at the front margin and the other costellae being nearly equal in size. Costellae along the front margin with less difference in size than the posterior and midregions. At front margin of a specimen 20 mm. long 15 costellae of nearly equal size occupy a space of 5 mm.

Pedicle valve with but a slight swelling in the umbonal region, nearly flat at about the middle where the valve is geniculated in the direction of the pedicle valve. Cardinal extremities deflected toward the brachial valve more or less strongly. Median region gently concave and this concavity is extended to the region of the cardinal extremities where the valve is slightly swollen. Interarea strongly apsacline, moderately long; delthyrium narrow, pseudodeltidium only moderately convex. Foramen minute.

Brachial valve moderately convex in lateral profile with the umbonal region flattened; high point of convexity at about the middle. Cardinal extremities set off by moderately deep grooves. Lateral and anterior slopes moderate. Umbonal region marked by a shallow sulcus visible for 5 to 8 mm. after which it fades into the general surface. Portions of valve bounding sulcus somewhat flattened.

Interior of pedicle valve: Teeth strong, moderately long; muscle area varying from subcircular to oval and in general having a length slightly greater than the width. Muscle field surrounded laterally by low ridge. Diductor-adjustor impressions subflabellate, separated by a low ridge. Adductor impressions located slightly posterior to the middle of the muscle field, slightly elevated on a low ridge. Subperipheral rim low, not greatly thickened.

Interior of brachial valve with short but slender brachiophores almost completely buried in secondary shell substance that forms the sockets. Median ridge low, extending to about one-third the distance to the front margin. Lobes of cardinal process small.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 22.3 | 21.1 | 27.4 | 30.1 | 4.5 |
| Paratype (117714b) | 21.4 | 20.2 | 25.1 | 26.7 | 4.0 |
| " (117714c) | 17.1 | 15.9 | 20.8 | 22.8 | 2.8 |

Types.—Holotype: 117714a; figured paratypes: 117708, 117712, 117713, 117714b-d, 123278; unfigured paratypes: 117709, 117710a-c, 117711a,b.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectra gouldi* zone and 20 feet above *O. gouldi* zone) in Carter County, Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Criner Hills; NW $\frac{1}{4}$ sec. 26, T. 5 S., R. 1 E., Criner Hills.

Discussion.—This species is characterized by the general uniformity in size of the costellae, the elongate muscle area, the flat umbonal region, and the short median sulcus of the brachial valve.

This species does not resemble any known *Strophomena* from the Appalachians but has its nearest relative in *S. inconsueta* C. L. Fenton. It is a wider shell relatively than *S. inconsueta* and differs further in the possession of a more elongate muscle area.

STROPHOMENA CRINERENSIS Cooper, new species

Plate 173, E, figures 25-30; plate 260, B, figures 11-25

Shell small for the genus, outline varying from semicircular to semielliptical. Hinge generally forming the widest part, cardinal extremities acutely angular, tending to alate. Surface marked by costellae of unequal size, the larger costellae separated by 3 or 4 much finer ones. All costellae crossed by prominent fila that give a cancellated appearance to the surface. At the front margin very fine costellae have increased sufficiently in size to reduce the inequality of the costellae.

Pedicle valve gently to moderately concave with the maximum concavity located at about the center. Umbonal region slightly and narrowly swollen; posterior half gently concave to nearly flat. Cardinal extremities flattened to slightly concave and deflected toward the brachial valve, a slight oblique fold forming the divide between the deflected cardinal extremity and the concave portions. Anterior geniculation not great. Interarea strongly apsacline; moderately long. Pseudodeltidium narrow and strongly arched. Foramen minute.

Brachial valve moderately to strongly convex in lateral profile, strongly convex in anterior profile. Greatest convexity of lateral profile at the middle or slightly anterior to the middle. Umbonal region gently concave, nearly flat to moderately deeply sulcate. Sulcus extending for about one-third the length. Oblique sulci just anterior to cardinal extremities deep. Lateral and anterior slopes moderately steep.

Interior: Muscle area subelliptical, slightly wider than long, its posterior half surrounded by delicate extensions from the teeth. Median ridge low, scarcely extending anterior to the front margin of the muscle area. Subperipheral rim corrugated, not greatly thickened. Interior of brachial valve with cardinal process well elevated, the brachiophores and their supporting tissue delicate. Musculature unknown.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 14.6 | 14.6 | 17.8 | 20.7 | 3.3 |
| Paratype (117716a) | 12.3 | 12.0 | 15.6 | ? | 4.0 |
| " (117717a) | 11.4 | 11.2 | 16.6 | 18.0 | 2.5 |
| " (117717d) | 12.8 | 12.5 | 18.2 | 19.8 ? | 4.4 |
| " (117717e) | 15.4 | 15.3 | 21.2 | 24.0 | 5.0 |

Types.—Holotype: 117718; figured paratypes: 117715, 117716a, 117717a-c, 117719a,c; unfigured paratypes: 117716b, 117717d,e, 117719b.

Horizon and locality.—Bromide formation (Pooleville member-*Oxoplectia gouldi* zone) in Oklahoma: At Rock Crossing of Hickory Creek, about center sec. 35, T. 5 S., R. 1 E., Carter County; Pooleville member, basal cobbly beds, Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County; just west of road on Russell Ranch, SE $\frac{1}{4}$ sec. 3, T. 2 S., R. 3 E., Murray County.

Discussion.—This species is characterized by its small size, short and wide pedicle muscle area, the cancellated pattern on the outside of the valves, and its generally great width. *Strophomena trentonensis* Winchell and Schuchert is the one described species most suggestive of *S. crinerensis*, but it differs in its more nearly quadrate form, nearly rectangular cardinal extremities, and generally larger size.

STROPHOMENA DELICATULA Fenton

Strophomena delicatula FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 155, pl. 9, figs. 4-6, 1928.

Types.—Holotype: Walker Mus. 25537; paratype: Walker Mus. 33400; figured specimen: Walker Mus. 25538.

Horizon and locality.—Barnhart formation in Missouri: 2 $\frac{1}{2}$ miles west of Ste. Genevieve, Weingarten (15') Quadrangle.

STROPHOMENA DIGNATA Fenton

Strophomena dignata FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 151, pl. 10, figs. 3-5, 1928.

Types.—Holotype: Walker Mus. 25532; paratypes: Walker Mus. 25533, 25535.

Horizon and locality.—Barnhart formation in Missouri: 2 $\frac{1}{2}$ miles west of Ste. Genevieve, Weingarten (15') Quadrangle.

STROPHOMENA EXIGUA Fenton

Strophomena exigua FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 152, pl. 10, fig. 6, 1928.

Type.—Holotype: Walker Mus. 25956.

Horizon and locality.—Upper part of Plattin group (Macy formation) in Missouri: South Beckett Hill, Weingarten (15') Quadrangle.

STROPHOMENA FASCICULATA Cooper, new species

Plate 256, B, figures 6, 7

Shell small, attaining a length of about 0.6 inch; subquadrate in outline; hinge straight, not equal to the greatest shell width which is at about the middle; sides gently rounded; anterior margin broadly rounded; costellae consisting of 2 sizes, a large and prominent set marking off fascicles of finer ones; 15 costellae in 5 mm. at the anterior margin, including 3 of the larger costellae.

Pedicle valve gently convex in lateral profile and with the maximum convexity in the posterior half; anterior half somewhat flattened; anterior profile nearly flat to very gently convex; umbonal region narrowly convex, the convexity continued anteriorly as a low fold beyond the middle; region just posterior to the middle gently swollen; flanks sloping gently from median region to the margins. Pseudodeltidium large, subcarinate.

Brachial valve gently convex with the maximum convexity somewhat anterior to the middle; posterior somewhat flattened; anterior profile broadly and gently convex; umbo marked by a shallow sulcus that extends to about the middle to merge with the slightly swollen anterior two-thirds; flanks with gentle lateral slopes.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 14.8 | 13.0 | 13.3 | 14.0 | ? |
| Paratype (117754b)..... | 10.4 | 9.6 | 13.1 | 10.2 | 2.2 |

Types.—Holotype: 117754a; figured paratype: 117754b; unfigured paratypes: 117754c-f.

Horizon and locality.—Peery formation in Tennessee: 7 miles southwest of Clinton, Clinton (T.V.A. 137-SW) Quadrangle.

Discussion.—This species is strongly costellate, and the costellae are strongly fasciculated. It suggests *Pionomena* but differs from *P. neumani* in having a less convex brachial valve, not so strong a development of the umbonal and median sulcus, and stronger costellae. It is one of the most strongly fasciculate species of *Strophomena*.

STROPHOMENA FILITEXTA (Hall)

Leptaena filitexta HALL, Pal. New York, vol. 1, p. 111, pl. 31B, fig. 3, 1847.

Strophomena filitexta (Hall) FENTON, Amer. Midland Nat., vol. 11, No. 9, pp. 500-503, pl. 38, figs. 1-5, 1929.

Fenton restudied the types of this species which has been widely misidentified in Middle Ordovician rocks. He indicates that the only species similar to *S. filitexta* are *S. auburnensis* and *S. plattinensis*, but they are distinct. He also states that the cotypes belong to the "typical black Trenton limestone." The specimen (pl. 38, fig. 1) which Fenton says is most clearly depicted by the original description is a large one having the width about $1\frac{1}{2}$ times greater than the length. The writer has seen none like this in the collections of Middle Ordovician fossils

studied, but a specimen in the National Collection from the Hull at Kirkfield, Ontario, is similar to the illustrated specimen.

STROPHOMENA FILITEXTA OBESA Wilson

Strophomena filitexta obesa WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 133, pl. 1, figs. 20-21, 1945; Geol. Surv. Canada, Bull. 8, p. 103, pl. 9, figs. 17a, b, 18, 1946.

Types.—Holotype: G.S.C. 7651; paratype: G.S.C. 7570.

Horizon and locality.—Leray=Rockland formation, in Ontario, Canada: Paquette Rapids, Ottawa River; southeast of Cumberland.

STROPHOMENA GRANDIMUSCULOSA Cooper, new species

Plate 256, C, figures 8-17

Shell of about medium size for the genus, wider than long and with the hinge forming the widest part; well-preserved specimens auriculate; sides somewhat oblique and indented just anterior to the cardinal extremities; anterior margin gently rounded. Costellae variable in size, fine and crowded, about 17 to 20 in 5 mm. at the anterior margin of an adult. Entire surface covered by fine concentric fila.

Pedicle valve moderately concave in lateral profile and with the maximum concavity at about the middle or slightly anterior to it. Umbo narrowly convex for a short distance only; median region concave; posterolateral extremities flattened. Interior with narrow, thin teeth and dental ridges; muscle area large, usually rhomboidal in outline, the anterior end reaching the middle of the valve or extending slightly anterior to it. Median ridge stout. Anterior ends of diductor scars usually elongate and making the anterior angle of the rhomb. Interarea moderately long, strongly apsacline; pseudodeltidium subcarinate. Foramen minute. Subperipheral rim moderately strongly developed.

Brachial valve moderately and fairly evenly convex in lateral profile; broadly and evenly convex in anterior profile; maximum convexity at about the middle or just anterior to it. Umbo forming a small, shallow concavity; median region swollen and with steep anterolateral and anterior slopes. Posterolateral slopes less steep than the others; cardinal extremities set out by a broad, oblique groove. Interior with small cardinalia, a short and low median ridge; adductor scars striated. Subperipheral rim moderately developed.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|--------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 21.1 | 19.1 | 25.3 | 29.2 | 3.5 |
| Paratype (117721b) | 23.2 | ? | 30.2 | 36.8 | ? |
| “ (117724a) | 21.4 | ? | 27.1 | 32.8 ? | ? |
| “ (117724b) | ? | 24.5 | 35.3 | 39.8 ? | ? |
| “ (117722) | 21.8 | 19.5 | 25.2 | 26.7 | 4.2 |

Types.—Holotype: 117721a; figured paratypes: 117720a, 117721b, 117722, 117724a,b; unfigured paratypes: 117720b, 117721c, 117723, 117724c.

Horizon and locality.—Lebanon formation (*Doleroides* zone) in Rutherford

County, Tenn.: On U. S. Highway 41, $\frac{3}{4}$ mile southeast of Knox Branch, about 9 miles southeast of Murfreesboro; on U. S. Highway 41, $1\frac{1}{2}$ miles northwest of Mount Olivet, 10 miles southeast of Murfreesboro; on U. S. Highway 70S, 0.4 mile southeast of Readyville; on U. S. Highway 241, $1\frac{1}{2}$ miles (map measure) southwest of Christiana; cut on U. S. Highway 41, $1\frac{1}{2}$ miles north of road to Big Springs about 1 mile southwest of Mount Carmel Church; on U. S. Highway 70S, 1.65 miles west of Cripple Creek, $1\frac{1}{2}$ miles west of Kittrell. On Tennessee Highway 16, 5.1 miles north-northwest of Shelbyville, Bedford County; Lewisburg; east end of the bridge over Round Lick Creek, on U. S. Highway 70N, at Rome, Smith County; near Lesters, south of Aspen Hill, Giles County; Columbia, Maury County; Rutherford Creek, 4 miles north of Columbia, Maury County.

Dryden formation in Tennessee: 30 feet above the marble on the road along Little Sycamore Creek, $\frac{1}{2}$ mile northeast of the west edge of the Howard Quarter (T.V.A. 162-NW) Quadrangle; Tennessee Highway 53 at Nicely and Palmer's store, $\frac{1}{2}$ mile east of Kate, Maynardville (30') Quadrangle.

Ooltewah formation in Tennessee: Northeast of Snow Hill Post Office, Snow Hill (T.V.A. 112-NW) Quadrangle.

Discussion.—This species is characterized by its rectangular outline, prominent ears, fine costellae, and large, thickened muscle region. It is most like *S. medialis* which also has prominent ears and a fairly wide rectangular outline. *Strophomena medialis* is, however, much more strongly costellate than *S. grandimusculosa*, and the muscle area is more rounded than in the Lebanon species.

STROPHOMENA GRANDIS (Okulitch)

Rafinesquina grandis OKULITCH, Canadian Field-Nat., vol. 49, No. 6, p. 98, pl. 1, fig. 2, 1935.

Strophomena grandis (Okulitch) SALMON, Journ. Paleont., vol. 16, No. 5, p. 598, pl. 87, figs. 29, 30, 1942.

Type.—Holotype: Peter Redpath Mus., McGill Univ., Montreal.

Horizon and locality.—Lowville formation in Quebec: At Pointe Claire.

Leray = Chaumont formation in Quebec: At St. Vincent de Paul.

STROPHOMENA INCONSUETA Fenton

Strophomena inconsueta FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 154, pl. 10, figs. 1, 2, 1928.

Types.—Holotype: Walker Mus. 25987; paratype: Walker Mus. 25989.

Horizon and locality.—Upper part of Plattin group (Macy formation) in Missouri: At South Beckett Hill, Weingarten (15') Quadrangle.

STROPHOMENA INCURVATA (Shepard)

Producta incurvata SHEPARD, Amer. Journ. Sci., vol. 34, p. 144, figs. 1, 2, 1838.—BASSLER, U. S. Nat. Mus. Bull. 92, p. 1229, 1915 (for complete bibliography to 1915).—FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 146, 1928.

Rafinesquina incurvata (Shepard) KAY, Bull. Geol. Soc. Amer., vol. 40, No. 1, p. 211, 1929.

This species has been widely identified from lower Middle Ordovician rocks. A variety of species has been erroneously named *Strophomena incurvata*. Ac-

cording to Kay this species does not belong to the genus *Strophomena*, and it occurs in Upper Ordovician rocks. Kay states as follows: "Shepard, in 1838, described *Producta incurvata* from near Navarino, at the head of Green Bay," Wis. The northern part of the present city of Green Bay was the town of Navarino in 1838. "*Strophomena incurvata* (Shepard)" has been commonly listed in paleontologic synonymy as a Black River or lower Trenton brachiopod. No Black River or lower Trenton rocks outcrop in the city. A study of the type locality reveals that a species of *Rafinesquina* is common in the Cincinnati shaly limestones on Ellis Creek, 3 miles east of the city of Green Bay. The species is of the genus *Rafinesquina*, not of *Strophomena*, and it seems identical with the form illustrated by Shepard as *Producta incurvata*.

Strophomena incurvata of authors, not of Shepard, a Black River and lower Trenton form, is thus a misidentification of *Rafinesquina incurvata* (Shepard), a Cincinnati species.

The writer has examined Shepard's figures of *Producta incurvata* and interprets them as belonging to *Strophomena* rather than *Rafinesquina*. The only way to settle this question is to examine the specimens, but Fenton (1928, p. 147) states that all his efforts to locate them proved futile, and he suggested abandonment of the species.

Kay's solution of the problem seems only half right. The writer will concede the Cincinnati age of the beds at Green Bay, but the possibility of Shepard's actually having had a *Strophomena* must not be overlooked. The genus occurs with *Rafinesquina* in Upper Ordovician rocks and cannot be ignored even though *Rafinesquina* is an abundant form at Green Bay. Shepard, in his description, speaks of the "shallow valve concave, basal margin incurved" which suggests *Strophomena*. His figure of the interior shows a short median ridge and the cardinalia as somewhat excavated, again suggesting *Strophomena*. Despite the generic affinities of the species, it probably belongs in the Upper Ordovician and can be dismissed from further consideration in the Middle Ordovician.

STROPHOMENA INSPECIOSA Willard

Plate 213, F, figures 26-34; plate 213, G, figures 35-38; plate 262, B, figures 8-11;
plate 264, B, figures 16-22

Strophomena inspeciosa WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 286, pl. 2, fig. 13, 1928.

As Willard points out, this species is suggestive of *Furcitella scofieldi* (Winchell and Schuchert) but differs markedly in its internal features. *S. inspeciosa* does not have the convex pedicle valve, and the brachial valve is still more convex than that of *F. scofieldi*. The contours of *S. inspeciosa* are those of the more familiar *Strophomena*.

Types.—Figured hypotypes: 117725, 117726, 117727a, 117728a,b, 117729a-e.

Horizon and locality.—Wardell formation and Wardell part of Dryden formation in Tennessee: At the bend of the railroad just west of Liberty Hill, Dutch Valley (T.V.A. 154-SE) Quadrangle; $\frac{1}{4}$ mile north of Emory Road, 2 miles northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle; *Hesperorthis* zone, and 40 feet below, Evans Ferry section along U. S. High-

way 25E, $\frac{1}{2}$ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; west of Lone Mountain, Tazewell (T.V.A. 154-NE) Quadrangle.

Wardell formation in Virginia: On Fugates Hill north of Mendota, Bristol (30') Quadrangle.

Ridley=Wardell formation in Georgia: On U. S. Highway 27 just north of its crossing over Chickamauga Creek, Kensington (T.V.A. 206-SE) Quadrangle.

Carters formation (*Oxoplectra* bed) in Alabama: Quarry 0.3 mile north of Gate City, Leeds (15') Quadrangle.

Mahan formation in Tennessee: 2 miles southeast of Snow Hill, Snow Hill (T.V.A. 112-NE) Quadrangle.

STROPHOMENA MAGNA Wilson

Strophomena magna WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 134, pl. 1, figs. 13, 14, 1945; Geol. Surv. Canada, Bull. 8, p. 104, pl. 9, figs. 11, 12, 1946.

Type.—Holotype: G.S.C. 7579.

Horizon and locality.—Rockland formation in Ontario, Canada: At Stewart Quarry, Rockland.

STROPHOMENA MEDIALIS Butts

Plate 259, A, figures 1-16

Strophomena medialis BUTTS, Virginia Geol. Surv. Bull. 52, pl. 87, figs. 1-6, 1942.

Large and thick, wider than long with the hinge forming the widest part; cardinal extremities alate; front margin broadly rounded; lateral margins usually oblique. Surface multicostellate with the larger costellae separated by 1 to 4 finer ones. All costellae enlarging anteriorly with the result that difference in size between primary and subsequent costellae is greatly lessened; 13 to 15 costellae occupy 5 mm. at the front margin of an adult.

Pedicle valve moderately to deeply concave with depressed part of valve occupying most of the surface. Cardinal extremities strongly deflected toward the brachial valve; surface of cardinal extremities flat to moderately concave. Umbonal region gently convex with the convexity continued anteriorly as a low fold for one-third to one-half the length of the valve. Interarea long and prominent, strongly apsacline; pseudodeltidium low, subcarinate.

Brachial valve moderately convex with the greatest convexity located slightly anterior to the middle. Posterior slope moderately steep, gently convex in profile; anterior slope somewhat steeper than the posterior one and also gently convex in profile. Median sulcus shallow but prominent, having about the same relation to the brachial valve that the fold of the pedicle valve has to that valve. Region about the sulcus gently swollen, with gentle to moderately steep slopes to the depressions setting off the deflected cardinal extremities, these depressions varying from gently to deeply concave. Lateral slopes moderately steep. Interarea exceedingly short, the palintrope forming a narrow ridge along the line of valve juncture. Chilidium short and low.

Interior of pedicle valve with a nearly circular to broadly cordate muscle area having a diameter equal to about one-third the valve length. Median ridge in-

conspicuous, narrow, low, and thin to absent. Delthyrial cavity shallow. Teeth small; dental ridges flaring, not reaching the middle of the muscle area. Inside the brachial valve muscle impressions and cardinalia confined to the posterior third; cardinal process moderately large.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Lectotype | 26.8 | 24.3 | 30.4 | 33.6 | 4.4 |
| Paratype (98201c) | 28.0 | 26.7 | 36.6 | 42.8 | 3.0 |
| Hypotype (117730b) | 26.1 | ? | 29.6 | 37.3 | ? |
| " (117730a) | 25.2 | 23.7 | 27.7 | 31.9 | 4.0 |

Types.—Lectotype: 98201a; paratypes: 98201b,c; figured hypotypes: 117730a,b, 117732a, 117733a, 117734a, 117737a.

Horizon and locality.—Wardell formation and Wardell part of Dryden formation in Virginia: 1 mile west of Rye Cove and several other points in the near vicinity of Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; Route 19, Little Indian Creek, 2½ miles west of Paint Lick, Richlands (15') Quadrangle; top 40 feet on Virginia Highway 610 at the southwest base of Paint Lick Mountain, Pounding Mill-Richlands (15') Quadrangles; quarry on Station Creek, ¼ mile south of U. S. Highway 58, 2 miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle; Mannville School, Clinchport (T.V.A. 188-NW) Quadrangle.

Same formations in Tennessee: On the north side of the road 1.1 miles north-east of Lee Valley, Lee Valley (T.V.A. 171-NW) Quadrangle; along the ridge just southwest of the old store near Hayes' house, Evans Ferry section on U. S. Highway 25E, ½ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; bend of the railroad just west of Liberty Hill, Dutch Valley (T.V.A. 154-SE) Quadrangle.

Discussion.—This species is abundant in the Wardell formation and is characterized by strong costellae, strong ears on the cardinal extremities, and moderate convexity. The species differs from *S. auburnensis nasuta* in having less convexity and different ornamentation. The costellae are stronger than those of *S. costellata* and *S. basilica*.

STROPHOMENA ? MILLIONENSIS AFFINIS Wilson

Strophomena? millionensis affinis WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 135, pl. 1, fig. 5, 1945; Geol. Surv. Canada, Bull. 8, p. 104, pl. 9, fig. 5, 1946.

Type.—Holotype: G.S.C. 7586.

Horizon and locality.—Leray (Chaumont)—Rockland beds in Ontario, Canada: On the Cobden-Eganville road.

STROPHOMENA MINUTA Wilson

Strophomena minuta WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 135, pl. 1, figs. 1-3, 1945; Geol. Surv. Canada, Bull. 8, p. 105, pl. 9, figs. 1-3, 1946.

Type.—Holotype: G.S.C. 7616.

Horizon and locality.—Leray=Chaumont formation in Ontario, Canada: At Stewart Quarry, Rockland.

STROPHOMENA MOLLIS Wilson

Strophomena mollis WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 136, pl. 1, fig. 4, 1945; Geol. Surv. Canada, Bull. 8, p. 105, pl. 9, fig. 4, 1946.

Type.—Holotype: G.S.C. 7588.

Horizon and locality.—Leray=Chaumont formation in Ontario, Canada: At Lots 3-5, concession III R. F., Gloucester Township.

STROPHOMENA MUSCULOSA Fenton

Strophomena musculosa FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 153, pl. 8, figs. 1-7, 1928.

Types.—Holotype: Walker Mus. 25524; paratypes: Walker Mus. 25527, 33421, 25525.

Horizon and locality.—Decorah formation (Ion member) in Minnesota: At Fountain, Goodhue County.

STROPHOMENA OKLAHOMENSIS Cooper, new species

Plate 260, A, figures 1-10

Shell small, wider than long, somewhat rectangular to semielliptical in outline. Cardinal extremities varying from an acute angle to a right angle. Lateral margins variable, slightly oblique to perceptibly convex; anterior margin gently convex. Surface marked by costellae of unequal size. A single costella intercalated between each of the primary costellae; one intercalated between each primary costella and the secondary one. This method of increase is continued on the entire surface. Intercalated costellae may grow to equal the primary costellae in strength. Consequently, the anterior parts of the valve do not show strong differentiation between the costellae; this is displayed on the posterior parts in varying degree depending on the individual specimen.

Pedicle valve gently concave in the front half, flattened or concave anterior to the cardinal extremities depending on age; cardinal extremities moderately deflected. Umbonal region narrowly convex, extended forward as a narrow but low fold nearly to the middle of the valve where the fold disappears in the general surface. Interarea very strongly apsacline; pseudodeltidium narrow, strongly arched.

Brachial valve moderately convex with the maximum curvature at about the middle or slightly posterior to the middle. Umbo sulcate, sulcus narrow and moderately deep, extending nearly to the middle of the valve. Area surrounding the sulcus flattened. Anterior and lateral slopes moderately steep; cardinal extremities not greatly deflected.

Interior of pedicle valve with a nearly circular muscle field not quite extending to the middle. Floor of muscle field moderately thickened, and slightly elevated; half enclosed by extensions from beneath the teeth. Median ridge low and short, extending about to the anterior ends of the diductor impressions. Teeth small. Subperipheral rim varying from obsolete (not developed) to moderately strong. Portion outside subperipheral rim narrow. Interior of brachial valve unknown.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 13.5 | 13.4 | 16.8 | ? | 2.9 |
| Paratype (117739a)..... | ? | 11.0 | 13.6 | 14.0 | ? |
| " (117739b)..... | 12.8 | ? | 16.6 | 17.3 | ? |

Types.—Holotype: 117738a; figured paratypes: 117739a,b; unfigured paratypes: 117738b, 117739c.

Horizon and locality.—Bromide formation (Pooleville member—just above zone with *Multicostella convexa*) in Oklahoma: At Rock Crossing of Hickory Creek, approximately center sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County; Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County.

Discussion.—This species is small in size like *S. crinerensis* but differs in its more uniformly square outline, strong median fold and sulcus, less-cancellated surface ornamentation, less-developed cardinal extremities, and details of the musculature.

STROPHOMENA OKULITCHI Cooper, new name

Plate 265, B, figures 3, 4

Strophomena corrugata OKULITCH (not Conrad 1842), Canadian Field-Nat., vol. 49, No. 6, p. 99, pl. 1, fig. 7, 1935.

This is a small, deeply concave species known only from the pedicle valve. The species is especially interesting because of the strong, coarse pseudopunctae arranged in rows as in *Rafinesquina*.

The new name is proposed to replace *Strophomena corrugata* Conrad, Journ. Acad. Nat. Sci. Philadelphia, vol. 8, p. 256, pl. 14, fig. 8, 1842, which preoccupies the Okulitch name.

Type.—Holotype: Peter Redpath Mus., McGill Univ., Montreal (no number).

Horizon and locality.—Leray=Chaumont formation in Canada: At St. Vincent de Paul, Quebec.

STROPHOMENA PLANOBESA Cooper, new species

Plate 261, A, figures 1-13; plate 261, B, figures 14-17

About average size for the genus, wider than long, hinge forming the widest part; sides straight or slightly oblique, indented anterior to the auriculate cardinal extremities. Anterior margin strongly rounded; costellae variable, alternating in size, 13 to 17 in 5 mm. at the front margin of a large adult.

Pedicle valve gently concave in lateral profile but with the posterior quarter slightly convex; greatest concavity just anterior to the middle; umbo narrowly swollen to form a short fold; flanks on each side of fold gently concave; median half gently concave; front half and sides deflected toward the pedicle valve. Interarea moderately long; pseudodeltidium wide and low, subcarinate.

Brachial valve unevenly convex in lateral profile, with the posterior quarter flattened but the median region strongly convex; anterior profile narrowly con-

vex with steep lateral slopes; umbonal region marked by a shallow and indistinct, short sulcus; area surrounding sulcus gently convex; median region tumid, with lateral and anterior slopes moderately long and very steep.

Interior of pedicle valve with thin and delicate dental processes and ridges; muscle area large, variable in outline from subcircular to oval; lateral margins of muscle field without elevated rim. Brachial interior with short, stout cardinal process, moderately long median ridge, and shallow, confined socket cups.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | ? | 18.8 | 21.0 | 19.0 | ? | 5.5 |
| Paratype (117740a) .. | 21.2 | ? | 24.0 | 25.8 | ? | ? |
| " (117740b) .. | 19.3 | ? | 20.6 | 21.4 | ? | ? |
| " (117740c) .. | 20.2 | ? | 21.6 | 21.1+ | ? | ? |
| " (117740d) .. | ? | 23.1 | 30.6 | 23.9 | ? | 7.1 |
| " (123279a) .. | ? | 20.8 | 23.2 | 21.0 | ? | 5.0 |
| " (123279c) .. | ? | 19.0 | 24.4 | 21.9 | ? | 5.5 |

Types.—Holotype: 117740f; figured paratypes: 117740c,e,g, 117741a-d, 123279a-c; unfigured paratypes: 117740a,b,d, 117741e,f.

Horizon and locality.—Ridley or Murfreesboro formation (with *Ancistro-rhyncha*) in Tennessee: On Crystal Creek, 5 miles south of Pikesville, Sequatchie Valley, Pikeville Special (15') Quadrangle.

Murfreesboro formation in Tennessee: Near the top of the formation at the crossing of U. S. Highway 70 and Stone River $1\frac{1}{2}$ miles northwest of Murfreesboro on the new armory grounds, Murfreesboro (15') Quadrangle.

Discussion.—This species is characterized by a gently concave pedicle valve but a fairly strongly convex brachial valve. It is also characterized by a squarish outline with small ears. The species is differently shaped and more evenly costellate than *S. basilica*. It differs in outline and ornamentation from *S. grandimusculosa* and *S. medialis*. No other species of the size of this one has the same convexity and outline.

STROPHOMENA PLANUMBONA (Hall)

Plate 265, A, figures 1, 2

This interior of the brachial valve is introduced for comparison with the brachial valve of *Furcitella* and other species referred to *Strophomena*.

Figured specimen.—117945.

Horizon and locality.—Liberty formation in Ohio: On Dodges Creek $1\frac{3}{4}$ miles northwest of Oxford.

STROPHOMENA PLANUMBONA PRAECIPITA Wilson

Strophomena planumbona praecipita WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 136, pl. 1, figs. 9, 10, 1945; Geol. Surv. Canada, Bull. 8, p. 106, pl. 9, figs. 9a, b, 1946.

Type.—Holotype: G.S.C. 1156a.

Horizon and locality.—Leray=Chaumont formation in Ontario, Canada: Above Mechanicsville, Ottawa.

STROPHOMENA PLATTINENSIS Fenton

Strophomena plattinensis FENTON, Amer. Midland Nat., vol. 11, Nos. 3, 4, p. 149, pl. 10, figs. 7-9, 1928.

Type.—Holotype: Walker Mus. 25988; paratypes: Walker Mus. 25501, 25983.

Horizon and locality.—Platteville formation in Wisconsin: At Mineral Point, Mineral Point (30') Quadrangle.

Plattin group (Macy formation) in Missouri: South Beckett Hill, Weingarten (15') Quadrangle.

STROPHOMENA PLATTINENSIS CRASSA Raasch

Strophomena plattinensis crassa Raasch, in SHROCK and RAASCH, Amer. Midland Nat., vol. 18, No. 4, pp. 549, 592, pl. 4, figs. 3, 7, 1937.

Horizon and locality.—Platteville formation (blue beds) in Wisconsin: At Beloit, Rock County; 2 miles west of Klevenville, Dane County.

STROPHOMENA PLATYUMBONA Cooper, new species

Plate 254, C, figures 7-10

Shell moderately large for the genus, wider than long and with the greatest width at the hinge. Cardinal extremities acute and subauriculate. Sides gently rounded and slightly oblique toward the middle; anterior margin somewhat narrowly rounded. Surface finely costellate, costellae subequal in size and numbering 3 to the millimeter at the front margin.

Pedicle valve fairly evenly concave in lateral profile and with the deepest part located just anterior to the middle; umbo only slightly swollen and the swelling continued anteriorly for a short distance only; median region flattened; sides and anterior abruptly bent in the direction of the pedicle valve to form a deeply concave region just anterior to the middle; cardinal extremities flattened and deflected in the direction of the brachial valve. Interior with narrowly elongated muscle field and with the diductor scars considerably elongated at their antero-median extremities.

Brachial valve with the posterior third gently concave, the median third moderately swollen and the anterior third gently convex in lateral profile. Anterior profile moderately and broadly convex. Lateral slopes moderately long, moderately steep; anterior slope somewhat steeper than the lateral ones. Interior with short median ridge, short brachioophores, and small cardinal process.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness | Height |
|-----------------------|--------|-----------------|----------|-------------|-----------|--------|
| Holotype | 29.0 | ? | 30.0 | 35.9 | ? | ? |
| Paratype (117743b) .. | 29.8 | ? | 33.5 | 35.3 | ? | ? |
| " (117743e) .. | 29.2 | 28.0 | 32.4 | ? | 4.9 | 7.0 |

Types.—Holotype: 117743a; figured paratypes: 117743b-d; measured paratype 117743e.

Horizon and locality.—Carters formation (*Oxoplectia* bed) in Alabama: In the quarry 0.3 mile north of Gate City, Leeds (15') Quadrangle.

Discussion.—This species is characterized by having a fairly large size and somewhat nasute front. It differs from *S. basilica* in having costellae of fairly even size and a more nasute front. It is unlike *S. medialis* in ornamentation and outline. It is also unlike *S. grandimusculosa* in being elongate rather than transverse and in having a less square and thickened muscle area in the pedicle valve. It has the form of *S. auburnensis nasuta* but is differently ornamented and has a smaller muscle area in the pedicle valve. It suggests *S. dignata* Fenton, but that species is larger, has a larger pedicle muscle scar and more differentiated ornamentation.

STROPHOMENA ROTUNDA Wilson

Strophomena rotunda WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 137, pl. 1, fig. 8, 1945; Geol. Surv. Canada, Bull. 8, p. 106, pl. 9, fig. 8, 1946.

Type.—Holotype: G.S.C. 7589.

Horizon and locality.—Leray=Chaumont—Rockland beds in Ontario, Canada: On road east from Skead, east of Ottawa.

STROPHOMENA ? SCULPTURATA Bassler

Plate 222, C, figure 4

Strophomena sculpturata BASSLER, Cambrian and Ordovician: Geol. Surv. Maryland, p. 250, pl. 49, fig. 1, 1919.

This is one of a number of species that have been described in North America and abroad which are characterized by the stropomenoid form but, in addition to the normal costellae, are more or less strongly wrinkled. The wrinkling is not like that of *Leptaena* but is more suggestive of *Bellimurina*. Little is known of the interior details of these species. The type of wrinkling displayed appears in many stocks that are demonstrably different, and this makes the wrinkling in itself a dubious character for generic differentiation. The same type of ornamentation also occurs in a rafinesquinoid stock.

Types.—Holotype: 66165; paratypes: 66165a-c.

Horizon and locality.—Martinsburg formation (*Sinuities* zone) in Pennsylvania: 1 mile south of St. Thomas, Mercersburg (15') Quadrangle.

STROPHOMENA SEPTATA Winchell and Schuchert

Strophomena septata WINCHELL and SCHUCHERT, Amer. Geol., vol. 9, p. 285, 1892; Geol. Minnesota, vol. 3, pt. 1, p. 390, pl. 30, figs. 1-3, 1895.

Horizon and locality.—Decorah formation (Ion member) in Minnesota.

STROPHOMENA VENUSTULA Wilson

Strophomena venustula WILSON, Trans. Roy. Soc. Canada, ser. 3, vol. 39, sec. 4, p. 138, pl. 1, figs. 6, 7, 1945; Geol. Surv. Canada, Bull. 8, p. 107, pl. 9, figs. 6, 7, 1946.

Types.—Holotype: G.S.C. 7591; paratype: G.S.C. 7599.

Horizon and locality.—Leray=Chaumont—Rockland beds in Quebec, Can-

ada: On Lot 24, concession VII, Allumette. In Ontario: At Mechanicsville, Ottawa.

STROPHOMENA sp. 1

Plate 257, C, figures 13-15

This species is known only from adult brachial valves and fragments of the pedicle valve. The brachial valve is strongly convex in lateral profile and has the maximum convexity located at about the middle. The anterior profile is broadly and strongly convex. The umbonal region is gently convex and forms a steep slope—steeper than the anterior one. The median region is strongly inflated. This Nevada species is most like *S. planobesa*, new species, in its profiles and general form, but it is more convex and has a somewhat different outline.

Figured specimen.—117742a.

Horizon and locality.—Just beneath the Eureka sandstone in Nevada: In the Antelope Range on the west side about 3 miles south of Ninemile Canyon, Roberts Mountains, (1°) Quadrangle.

Suborder DICTYONELLOIDEA Cooper, new suborder

Shells having a smooth umbonal attachment for the pedicle.

Family EICHWALDIIDAE Schuchert, 1893

Usually triangular shells with narrow lateral grooves in the brachial valve for articulation.

Genus EICHWALDIA Billings, 1858

Eichwaldia BILLINGS, Geol. Surv. Canada, Rep. on Progress for 1857, p. 190, 1858.

EICHWALDIA SUBTRIGONALIS Billings

Plate 163, A, figures 1-6

Eichwaldia subtrigonalis BILLINGS, Geol. Surv. Canada, Rep. on Progress for 1857, p. 192, fig. 24, 1858; Canadian Nat. Geol., vol. 3, p. 443, fig. 24, 1858; Geol. Canada, p. 142, fig. 76, 1863.—HALL and CLARKE, Pal. New York, vol. 8, pt. 2, p. 310, figs. 241, 242, pl. 83, figs. 1-4, 1893.—WILSON, Geol. Surv. Canada, Bull. 8, p. 120, pl. 8, figs. 6-9, 1946.

Types.—Holotype: G.S.C. 1145a; paratypes: G.S.C. 1145b-g; hypotype: G.S.C. 6418; figured hypotypes: U.S.N.M. 92369d,f.

Horizon and locality.—Rockland formation in Canada: Paquette Rapids, Ottawa River, Ontario; Allumette Island, Ottawa River, Quebec.

Suborder DALMANELLOIDEA Moore, 1952

Punctate brachiopods with orthoid-type cardinalia.

Superfamily DALMANELLACEA Schuchert and Cooper, 1931

Family DALMANELLIDAE Schuchert, 1929

(= WATSELLIDAE Schuchert and Cooper, 1931)

Dalmanellacea with subcircular or shield-shaped shells having a cordate pedicle muscle field and fulcral plates defining the sockets.

Genus *DALMANELLA* Hall and Clarke, 1892

Dalmanella HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 205, 223, 1892.—ÖPIK, Acta et Comment. Univ. Tartu, ser. A, vol. 25, No. 1, p. 14, 1933.

Wattsella BANCROFT, Mem. Manchester Lit. Phil. Soc., vol. 72, p. 55, 1928.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 125, 1932.

DALMANELLA COSTELLATA Cooper, new species

Plate 158, E, figures 17-33

Shell small for the genus, oval in outline; sides and anterior margin strongly rounded; anterior commissure gently sulcate; valves unequally convex, the brachial valve having the lesser convexity. Costellae numbering 3 to the millimeter at the anterior margin; spaces between costellae marked by strong, closely spaced fila.

Pedicle valve strongly convex in lateral profile with the maximum convexity at the middle; anterior profile strongly convex. Beak bluntly rounded; umbo narrowly swollen and merging into the strongly swollen median region; anterior and lateral slopes steep. Interarea long, curved, gently apsacline.

Brachial valve gently convex in lateral profile; anterior profile gently concave, the median region a shallow concavity bounded by flattened flanks. Umbo sulcate, the sulcus widening anteriorly to the front margin where it is broad and shallow. Flanks gently swollen; lateral slopes short and gentle.

Pedicle interior with short, stout dental plates, subcordate muscle field, stout teeth, and thick vascula media. Brachial valve with long, narrow, and deep notothyrial cavity; fulcral plates stout, obsolete in old specimens. Cardinal process small. Anterior adductor pair larger than the posterior pair.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.7 | 7.9 | 8.8 | 5.6 | 4.5 |
| Paratype (117359a)..... | 7.5 | 6.8 | 7.7 | 4.0 | 4.3 |
| " (117359b)..... | 7.8 | 6.8 | 7.8 | 3.6 | 4.0 |
| " (117359c)..... | 7.2 | 6.6 | 7.1 | 4.1 | 3.9 |
| " (117359d)..... | 8.8 | 7.9 | 8.8 | 6.0 | 4.6 |

Types.—Holotype: 117359f; figured paratypes: 117359a,e, 117360b,c; unfigured paratypes: 117359b-d, 117360a,d.

Horizon and locality.—Oranda formation in Virginia: Just west of the junction of Virginia County Highways 617=910, and 777, $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle; 0.6 mile northwest of Linville Station, Broadway (15') Quadrangle; on U. S. Highway 11, 1 mile southwest of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species is characterized by its narrow hinge, elongate-oval form, fine costellae, and gentle sulcus. It differs from *D. sculpta* in its oval form and finer costellae. The species is abundant in some exposures of the Oranda formation where it occurs as impressions of the interior and exterior. The interior impressions show the great variation of the brachial structures which range from typical *Dalmanella*, with well-marked brachiophore supports at-

tached to the median ridge, to forms in which the fulcral plates are nearly or quite obsolete.

DALMANELLA CRASSICOSTELLATA Cooper, new species

Plate 121, B, figures 2-8; plate 146, C, figures 24-30

Shell small, rectangular in outline, wider than long; hinge slightly less than the greatest width which is at the middle; sides gently rounded; anterior margin broadly rounded; anterior commissure somewhat narrowly sulcate; costellae strong, 2 to the millimeter at the front margin.

Pedicle and brachial valves about equal in depth; pedicle valve with gentle convexity in lateral profile; narrowly convex in anterior profile and with long, steep lateral slopes; umbo subcarinate, the carina extending to the front margin as a strong fold. Flanks bounding fold sloping moderately steeply to the margins. Beak low, slightly incurved.

Brachial valve with gentle convexity in lateral profile; anterior profile with narrowly depressed middle bounded by 2 low humps; umbo sulcate, sulcus narrow and deep from beak to margin; flanks bounding sulcus moderately swollen; lateral slopes long and gentle to the margins. Interior with long brachiphore plates uniting with the median ridge; cardinal process with long shaft and small myophore.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.2 | 8.9 | 11.1 | 9.0 | 3.4 |
| Paratype (117361a).... | 6.7 | 6.2 | 8.3 | 7.2 | 3.6 |
| " (117361b).... | 8.8 | 7.8 | 10.1 | 8.0 | 3.3 |
| " (117361c).... | 9.4 | 8.7 | 10.6 | 9.5 | 3.4 |

Types.—Holotype: 117361d; figured paratypes: 117361a,e,f; unfigured paratypes: 117361b,c,g-i.

Horizon and locality.—Lower Hermitage formation in Tennessee: Along Tennessee Highway 53, 0.7 mile south of Woodbury, Woodbury (15') Quadrangle.

Discussion.—This species is common in the lower part of the Hermitage formation in West Tennessee. It can be recognized by its wide hinge, deep sulcus, and fairly thick contour when compared to *Onniella planoconvexa* Cooper with which it occurs. It has about the same size as *D. rara* but generally is not as thick as that species, is somewhat more finely costellate, and has a less prominent sulcus than the East Tennessee form. This species is much smaller in size than *D. sulcata* and has a much shallower sulcus.

DALMANELLA RARA Cooper, new species

Plate 126, I, figures 46-51; plate 157, B, figure 4; plate 158, A, figures 1-5;
plate 161, B, figures 17-22; plate 162, C, figures 13-18

Shell of about medium size for the genus, subrectangular in outline; wider than long, with a wide hinge; greatest width at the middle; sides gently rounded;

anterior margin strongly rounded; anterior commissure sulcate. Costellae numbering 2 (rarely 3) to the millimeter at the front margin.

Pedicle valve gently convex in lateral profile, with the maximum curvature just posterior to the middle and the front half to third somewhat flattened; anterior profile broadly triangular. Umbo narrowly convex, the convexity continued to the front margin to form a low fold; flanks bounding fold flat in profile and sloping steeply to the margins. Beak long; interarea long, apsacline.

Brachial valve most convex in the posterior half when seen in lateral profile, the front half flattened. Anterior profile forming 2 low mounds separated by a shallow depression. Sulcus deep and narrow, widening and becoming shallower toward the anterior margin. Flanks bounding sulcus moderately and somewhat narrowly swollen; lateral slopes low and gently sloping.

Interiors as usual in the genus; the pedicle valve having short, flaring dental plates and the brachial valve with prominent parallel brachiophore supports.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.2 | 9.4 | 11.5 | 9.1 | 4.8 |
| Paratype (117362a).... | 8.0 | 7.2 | 9.5 | 8.9 | 4.8 |
| " (117362b).... | 7.8 | 7.3 | 9.2 | 8.3 | 3.4 |

Types.—Holotype: 117362c; figured paratypes: 96362e, 117362a,b, 117363a, d,e,g.

Horizon and locality.—Curdsville formation in Tennessee: On Tennessee Highway 33, 5½ miles northeast of Maynardville, Maynardville (T.V.A. 145-SE) Quadrangle; ½ mile north of Sill (now under Norris Lake), lat. 36° 17' 31", long. 83° 53' 55", White Hollow (T.V.A. 145-SW) Quadrangle.

Same formation in Virginia: At Pennington Gap, Lee County.

Discussion.—This species is characterized by a fairly robust form although it is not nearly so large a shell as *D. sulcata*. It has a wide hinge with gently obtuse cardinal extremities, fairly strong costellae, and a moderately deep sulcus. *Dalmanella rara* is most like *D. crassicostellata* but differs in its larger size, thicker contour, deeper sulcus and somewhat finer costellae. The species is also identified on the type slab of *Onniella fertilis* (Ulrich). On the reverse side of this slab to that which is figured a number of brachial interiors appear which have the subparallel brachiophore plates united with the median ridge that so characterizes *Dalmanella*. The specimens are here referred to *D. rara* and have the same association with *O. fertilis* as occurs at the locality northeast of Maynardville. The same association was found in silicified material etched from Trenton limestone collected ½ mile north of the submerged settlement of Sill in the White Hollow (T.V.A. 145-SW) Quadrangle, Tenn.

DALMANELLA SCULPTA Cooper, new species

Plate 158, F, figures 34-46

Shell of about medium size for the genus, subcircular in outline; hinge narrow; sides and anterior margin strongly rounded; anterior commissure gently

sulcate. Costellae strong, narrowly rounded or subangular, numbering about 2 to the millimeter at the anterior margin. Interspaces with strong fila often producing a beaded effect.

Pedicle valve moderately strongly convex in lateral profile with the maximum convexity just posterior to the middle; anterior profile strongly convex and with steep lateral slopes. Umbo narrowly rounded, the folding continuing to a point at or just anterior to the middle. Median region swollen; anterior and lateral slopes convex, steep. Beak incurved; interarea short, curved, apsacline.

Brachial valve evenly and moderately convex in lateral profile; broadly and gently convex in anterior profile but with the median region gently depressed; umbo sulcate, the sulcus increasing in width anteriorly where it is broad and shallow; flanks bounding sulcus gently inflated. Interior of young brachial valves with convergent and subparallel brachiphore plates but poorly developed fulcral plates. Cardinal process small, with thin shaft. Adults with thickened and encrusted brachiphores and fulcral plates obsolete. Anterior adductor pair much larger than the posterior pair.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.0 | 10.3 | 11.5 | 6.4 | 5.8 |
| Paratype (117364a)... | 10.0 | 9.0 | 10.0 | 6.2 | 4.5 |
| " (117364b)... | 7.5 | 6.8 | 7.4 | 4.6 | 3.7 |

Types.—Holotype: 117364c; figured paratypes: 117364a,d,e; unfigured paratypes: 117364b,f-i.

Horizon and locality.—Martinsburg formation (part with *Brongniartella*=Salona formation) in Broadway (15') Quadrangle, Virginia: On Virginia County Highway 617=910, about 0.15 mile north of Green Mount Church; 0.6 mile northwest of Linville Station.

Discussion.—This species is characterized by its circular outline, small, suberect beak, gentle sulcus, moderately strong costellae with prominent fila that often produce a beaded effect on the costellae. The species is suggestive of *D. costellata* which occurs in the Oranda formation just below the Salona. It differs, however, in not having the oval form and fine ribbing of the Oranda species.

This species shows an interesting feature besides the development of the beaded costellae. In two specimens the myophore has a high-crested median ridge suggestive of *Cristiferina*, but the cardinalia are not like those of that genus. The beak regions of many specimens were cleaned out in an effort to learn the constancy of this feature, but most of the specimens, after careful preparation, failed to show the strong myophore crest.

DALMANELLA SULCATA Cooper, new species

Plate 161, A, figures 1-16

Shell of about medium size for the genus, subrectangular in outline; wider than long; maximum width at or near the middle; hinge narrow, about two-

thirds the width; sides gently rounded to nearly straight; cardinal extremities obtuse, narrowly rounded; anterior margin strongly rounded; anterior commissure narrowly sulcate. Costellae numbering 2 or 3 to the millimeter at the front margin.

Pedicle valve deeper than the brachial valve, gently convex in lateral profile with the maximum convexity at the umbo; anterior profile forming a broad triangle, the median region carinate and the sides sloping moderately. Beak low, incurved; umbo carinate, the carina continuing from the beak to beyond the middle and becoming more rounded in the anterior third, thus forming a fold from beak to margin. Median region inflated. Interarea moderately long, curved, apsacline.

Brachial valve gently convex in lateral profile and with the anterior third somewhat flattened; anterior profile bilobed, with 2 convex lobes with a shallow depression occupying the middle between them. Umbo deeply sulcate; sulcus narrow, extending to the anterior margin and becoming wider and shallower in its passage to the front margin. Flanks bounding sulcus moderately inflated; lateral slopes short and gentle.

Pedicle interior with small teeth, flaring dental plates with a thickening anterior to them and enclosing the sides of the muscle area; diductor scars elongate, separated anteriorly; adductor field narrowly elliptical. Brachial interior with brachiphores united to median septum; cardinal process with moderately long, cleft shaft and small myophore.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.4 | 10.7 | 13.2 | 9.9 | 4.9 |
| Paratype (117365b) | 12.8 | 12.4 | 15.7 | 10.2 | 5.4 |
| " (117365c) | 11.7 | 11.1 | 13.9 | 9.3 | 5.0 |

Types.—Holotype: 117365a; figured paratypes: 117365b,e,f,h,i, 123239a; unfigured paratypes: 117365c,d,g.

Horizon and locality.—Hermitage formation (base) in Tennessee: On U. S. Highway 70S-41 near its junction with Spence Lane, 4.2 miles southeast of Nashville, Hermitage (15') Quadrangle.

Discussion.—This is a large species characterized by robust form, subrectangular, fine costellae and deep sulcus and corresponding subcarinate fold on the pedicle valve. It is the largest species of *Dalmanella* described herein and differs from all others in this monograph in that respect. It differs from *D. crassicostellata* also in having finer costellae, deeper sulcus, and stronger fold.

Some of the specimens are characterized by nearly right angled cardinal extremities, but in others the cardinal extremities are strongly rounded. In other respects these specimens are like the more typical square-shouldered forms. The ones with rounded cardinal extremities may ultimately prove to be related to *Onniella* rather than *Dalmanella*, but this could not be demonstrated with the collections available.

DALMANELLA WINCHELLI Cooper, new name

Plate 158, D, figures 15, 16

Orthis (Dalmanella) hamburgensis ? WINCHELL and SCHUCHERT (not Walcott, 1884), Geol. Minnesota, vol. 3, pt. 1, p. 440, pl. 33, figs. 14-16, 1895.

This new name is proposed for *Dalmanella hamburgensis* Winchell and Schuchert which is totally unlike *Orthis hamburgensis* Walcott from the Lower Ordovician (Goodwin formation) of the Eureka District, Nev. The Nevada shell is the type species of the genus *Nanorthis*, whereas the Minnesota shell has the structure of true *Dalmanella*.

Figured specimens.—48758a,b.

Horizon and locality.—Decorah formation (Guttenberg member-*Rhinidictya* bed) in Minnesota: At St. Paul.

Discussion.—The National Museum collection contains a few coarsely costellate dalmanellids with wide hinge that may ultimately prove to belong to the genus *Dalmanella* with nearest relationships to *D. winchelli*. These occur at several horizons.

Family ONNIELLIDAE Öpik, 1933

Dalmanellacea in which the muscle field of the pedicle valve is bilobed, the diductor scars not enclosing the adductor impressions. Brachioophores simple and bladelike, without fulcral plates in the adult.

Genus ONNIELLA Bancroft, 1928

Onniella BANCROFT, Mem. Manchester Lit. Phil. Soc., vol. 72, p. 55, 1928; Journ. Paleont., vol. 19, No. 3, p. 211, 1945.

ONNIELLA ? AMERICANA Cooper, new species

Plate 37, C, figures 8-14

Shell attaining a width of about $\frac{3}{4}$ inch, wider than long, subrectangular in outline; sides broadly rounded; anterior margin nearly straight. Brachial valve convex; pedicle valve convex at the rear but moderately concave in the median region. Surface multicostellate, costellae numbering 2 or 3 to the millimeter at the front margin.

Pedicle valve moderately concave in lateral profile, broadly concave in anterior profile. Beak small, umbo subcarinate, the angulation continued anteriorly as a low and narrow fold nearly to the front margin. Fold at front margin broad and shallow. Flanks bounding fold concave. Posterolateral and lateral extremities flattened. Interarea short, apsacline. Pedicle muscle field subquadrate, moderately large.

Brachial valve evenly and gently convex in lateral profile, broadly and gently convex in anterior profile but with the middle marked by a narrow depression. Umbo sulcate, sulcus extending to anterior margin, narrow in the posterior two-thirds but widening anteriorly. Flanks bounding sulcus narrowly rounded; lateral slopes short, moderately steep.

Measurements in mm.—Holotype, length 15.1, brachial length 15.1, midwidth 20.6, hinge width 13.8, thickness 3.6.

Types.—Holotype: 116964a; figured paratype: 116964b.

Horizon and locality.—Lower Hermitage formation in Tennessee: Along Tennessee Highway 53, 1 to 1½ miles south-southeast of Woodbury (15') Quadrangle.

Discussion.—The generic identity of this species has caused considerable difficulty. The species was at first thought to be a member of the *Dinorthisidae* but flakes of the shell heated in a blast lamp showed definite punctae. As a dalmanellid the genus *Onniella* seems the most likely assignment at the present time, but the species is resupinate and is the only member of the genus *Onniella* having this profile. It is probable that the species belongs to a genus not yet described.

Paratype 116964b was roasted in a blast lamp and part of the shell peeled off to reveal the pedicle muscle field. This proved to be subquadrate, but details of the brachial interior were not clear because of partial silification of the shell and crystallinity of the matrix. The brachial processes are flat blades like those of *Onniella*.

ONNIELLA FERTILIS (Ulrich)

Plate 157, A, figures 1-3; plate 157, C, figures 5, 6; plate 159, E, figures 21-37

Orthis (Dalmanella) testudinaria HAYES and ULRICH (not Dalman), U. S. Geol. Surv., folio 95, Illustr. Sheet, figs. 42, 43, 1903.

Orthis (Dalmanella) fertilis ULRICH in BASSLER, Virginia Geol. Surv. Bull. 2A, p. 182, pl. 24, fig. 5, 1909.

Shell large for the genus, planoconvex; width about 1½ times the hinge width; posterolateral extremities narrowly rounded; sides moderately rounded; anterior margin strongly rounded; anterior commissure rectimarginate to slightly sulcate. Costellae generally 2 to 1 mm. at the front margin, in places 3 to the millimeter.

Pedicle valve gently convex in lateral profile with the maximum convexity in the umbonal region; anterior profile broadly triangular, the median region narrowly convex to carinate with long, gently dipping lateral slopes. Beak small, low; umbo narrowly convex, the convexity continued anteriorly as an indistinct fold; interarea short, curved, apsacline.

Brachial valve nearly flat in both profiles; umbo narrowly sulcate, the sulcus extending anteriorly to the front margin but scarcely widening anteriorly; lateral regions gently concave to nearly flat; posterolateral extremities flattened and deflected slightly toward the pedicle valve.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (117369a)..... | 16.0 | 15.3 | 20.1 | 12.0 | 4.5 |
| " (117369b)..... | 12.8 | 12.3 | 15.8 | 11.5 | 5.0 |

Types.—Lectotype: 96362b; paratypes: 96362a,c,d; figured hypotypes: 117369a-d, 123238a,b.

Horizon and locality.—Curdsville formation in Virginia: On U. S. High-

way 58, 3 to 3 $\frac{1}{4}$ miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle; Pennington Gap, Lee County.

Same formation in Tennessee: Lat. 36° 17' 31", long. 83° 53' 55", $\frac{1}{2}$ mile north of Sill (locality now under waters of Norris Lake), White Hollow (T.V.A. 145-SW) Quadrangle.

Discussion.—This species is characterized by its large size, nearly flat brachial valve, and fairly fine costellae. The species has been widely identified on the west side of the Appalachians, in Kentucky and West Tennessee. The species is fairly characteristic in Curdsville rocks, but references to it in the Hermitage formation are probably erroneous.

The authorship and type specimen of this species need explanation and description. In his reference to the species on page 82, Bassler (1909) gives Ulrich as the author. In the plate legend no author's name is used. Inasmuch as there is no description of the species by Bassler and none has ever been given since 1909, it seems apparent that Bassler was citing a species Ulrich had studied and intended to describe.

In the plate legend (pl. 24) no enlargement is given for the specimen illustrated. Comparison of the specimen and picture indicate an enlargement of $\times 1\frac{1}{2}$. The specimens, except for one, are thus all small individuals. The exception mentioned is the pedicle interior of a large specimen, and a brachial interior of nearly the same size appears on the same piece. This is not shown in the illustration but must be numbered among the cotypes. Comparison of the illustrated slab with a good suite of shells of all sizes from the Curdsville formation, 5 $\frac{1}{2}$ miles northeast of Maynardville, Tenn., on Tennessee Highway 33 shows that the small individuals so abundant on the type slab are actually the young of a larger form. The larger forms from Maynardville are identical with the large interiors on the type slab. The writer therefore selects as type of the species the brachial interior mentioned above and here designated 96362b. This specimen shows the generic characters well.

Several localities and stratigraphic levels produce *Onniellas* strongly suggestive of *O. fertilis*. Most of these are undescribed species outside the scope of this monograph. *Onniella fertilis* differs from *O. planoconvexa* from the Hermitage of West Tennessee in its greater size and more transverse form.

ONNIELLA PAQUETTENSIS Sinclair

Onniella paquettensis SINCLAIR, Canadian Field-Nat., vol. 59, No. 3, p. 73, pl. 2, figs. 2, 3, 1945.

Horizon and locality.—Rockland formation in Ontario, Canada: Paquette Rapids on the Ottawa River.

ONNIELLA ? PLANOCONVEXA Cooper, new species

Plate 161, C, figures 23-36

Shell of about medium size for the genus, roundly elliptical in outline, with strongly rounded sides and anterior margins. Anterior commissure faintly sul-

cate. Hinge narrow; cardinal extremities rounded. Costellae numbering 2, rarely 3, to the millimeter at the front margin.

Pedicle valve shallow, gently convex in lateral profile, broadly triangular in anterior profile, the median region subcarinate, the sides flat, long, and moderately steep. Umbo and median region narrowly convex and forming a narrow, low fold to the anterior margin. Beak low, small; interarea short and strongly curved. Interior with small teeth and short, flaring dental plates; muscle area heart shaped, wide.

Brachial valve nearly flat in lateral profile; very gently convex in anterior profile but with the median region gently depressed by a sulcus. Umbo sulcate, the sulcus widening to the anterior margin where it is broad and shallow. Flanks bounding sulcus gently swollen; lateral slopes gentle. Brachial interior with small brachiophores having short supporting plates which are united to the median ridge; cardinal process small with slender shaft and small myophore.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.2 | 9.8 | 11.5 | 6.5 | 3.9 |
| Paratype (117370a) | 11.7 | 11.4 | 13.0 | 7.7 | 4.2 |

Types.—Holotype: 117370b; figured paratypes: 117365c-e, 117370a; unfigured paratypes: 117365a,b.

Horizon and locality.—Base of Hermitage formation in Tennessee: Along Tennessee Highway 53, from 0.7 to 1.5 miles south of Woodbury, Woodbury (15') Quadrangle.

Discussion.—This species has usually been referred to *Onniella fertilis* (Ulrich) but the Curdsville form is a larger shell, more transversely elliptical in outline, more convex, and with a proportionally wider hinge. The Hermitage species is distinctly subcircular in outline.

Genus PAUCICRURA Cooper, new name

(Latin *paucus*, few; *crus*, leg)

Dalmanella SCHUCHERT and COOPER (not Hall and Clarke), Mem. Peabody Mus. Nat. Hist., vol. 4, pt. I, p. 120, 1932.

In amplifying Bancroft's genus *Resserella*, Schuchert and Cooper (1932 p. 126) restricted Bancroft's designation of *Orthis canalis* Sowerby, 1839, in Murchison, Silurian System, to the specimen illustrated on plate 13, figure 12a, as type of the genus. This selection now proves most unfortunate because the specimen chosen is a member of the genus *Parmorthis*. The two genera, *Resserella* and *Parmorthis*, are thus synonyms, and the latter must be suppressed in favor of *Resserella* which is the older genus. The large series of shells formerly assigned to *Resserella* are thus left without a name. I propose *Paucicrura* to serve in this capacity and designate *Orthis rogata* Sardeson as type species of the genus. The familiar Silurian *Parmorthis* thus becomes *Resserella* and our *Resserellas*, which are numerous, become *Paucicrura*.

I am grateful to Dr. C. J. Stubblefield, Geological Survey of Great Britain, London, for calling my attention to this unhappy situation.

PAUCICRURA MATUTINA Cooper, new species

Plate 159, B, figures 6-11

Shell of about medium size for the genus, subcircular in outline; hinge moderately wide; sides gently rounded, anterior margin more strongly rounded; anterior commissure faintly sulcate; costellae moderately strong, 2 or 3 to the millimeter at the anterior margin.

Pedicle valve gently convex in lateral view; triangular in anterior profile and with flat, long, moderately steep lateral slopes; umbo narrowly convex, the convexity continued anteriorly to beyond the middle where it becomes less strong; anterior slope gently convex, long, and gently inclined; beak small; interarea moderately long, gently curved, apsacline. Interior with strong teeth, short and stout dental plates.

Brachial valve very gently convex in both profiles but with the anterior profile depressed medially by a shallow sulcus. Umbo sulcate, sulcus widening anteriorly and becoming shallower in the same direction; flanks bounding sulcus gently inflated. Interior with stout, short, slightly divergent brachiophores, median ridge low, cardinal process with long shaft but small myophore.

Measurements in mm.—Holotype, length 7.3, brachial length 6.7, width 7.9, hinge width 6.2, thickness 3.2.

Types.—Holotype: 111795a; figured paratypes: 117366a,b.

Horizon and locality.—Edinburg formation (lower *Cyrtonotella* zone) in Virginia: In the ravine at the switch just east of Strasburg Junction, Strasburg (15') Quadrangle.

Shippensburg formation (Pinesburg member-lower part *Echinosphaerites* zone) in Pennsylvania: Along the railroad 2 miles southwest of Marion, Chambersburg (15') Quadrangle.

Same formation in Maryland: On U. S. Highway 40, on the west bank of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—This species is one of the earliest dalmanellids so far found in the United States. It is characterized by subcircular outline, moderately wide hinge, fine costellae, and moderately deep sulcus. It is close to *P. virginica* but has stronger costellae, a less deep sulcus and a more gentle fold on the pedicle valve.

PAUCICRURA ROGATA (Sardeson)

Plate 157, F, figures 18-24

Orthis rogata SARDESON, Minnesota Acad. Nat. Sci., Bull. 3, p. 331, pl. 5, figs. 1-4, 1892; Amer. Geol., vol. 19, p. 95, pl. 4, figs. 1-10, 1897.

Orthis (Dalmanella) testudinaria (Winchell and Schuchert, not Dalman), WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 441, pl. 33, figs. 17-22, 1895.—HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pl. 5B, figs. 27-31, 1892.

Dalmanella rogata (Sardeson) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 120, pl. 17, figs. 2-5, 7, 13, 31, 1932.

Figured specimens.—48701a,b.

Horizon and locality.—Upper Decorah (Ion shale—Fucoid bed) and lower Prosser (*Vellamo* bed) in Minnesota: At Spring Valley, Fillmore County; Cannon Falls, Goodhue County; St. Paul; Kenyon, Goodhue County; Rochester, Olmsted County; Fountain, Fillmore County; Warsaw, Rice County.

Same formation in Wisconsin: At Mineral Point, Mineral Point (30') Quadrangle; Highland, Iowa County.

Auburn chert in Missouri: $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle.

PAUCICRURA SUBPLANA Cooper, new species

Plate 159, D, figures 14-20

Shell of about moderate size for the genus, slightly wider than long; sides and anterior margin strongly rounded; anterior commissure faintly sulcate. Finely costellate and with about 70 costellae around the margin of the pedicle valve.

Pedicle valve fairly strongly convex in lateral profile and with the maximum convexity in the posterior half; anterior profile roundly subcarinate and strongly arched; umbonal region narrowly swollen; median region swollen and with a steep anterior slope; sides flattened but steep; interarea short, curved; beak small.

Brachial valve nearly flat in lateral profile; anterior profile slightly convex and depressed medially by a shallow, narrow sulcus; sulcus originating at the umbo, broad and shallow, almost obsolete at the front margin. Flanks slightly swollen and with short, gentle slopes to the margins.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|----------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 10.0 | 9.2 | 10.6 | 6.5 | 4.5 |
| Paratype | 9.1 | 8.5 | 10.0 | 6.4 | 4.2 |

Types.—Holotype: 123237a; figured paratype: 123237b.

Horizon and locality.—Martinsburg formation (part with *Brongniartella*=*Salona*) in Virginia: On County Highway 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is characterized by its fine costellae and the nearly plane brachial valve. It is separated from *Dalmanella sculpta*, with which it occurs, by these features. Although the interior is at present not known, the species is referred to *Paucicrura* because of the nearly flat brachial valve. It differs from *P. virginica* in being more circular and in having much finer costellae. The species is suggestive of *P. rogata*, but that species has a wider hinge and distinct shoulders as well as stronger ornamentation.

PAUCICRURA VIRGINICA Cooper, new species

Plate 159, A, figures 1-5; plate 160, A, figures 1-10

Shell of about usual size for the genus, slightly wider than long, subquadrate to subcircular in outline; hinge wide, greatest width at about the middle; sides

and anterior margin gently rounded; anterior commissure faintly sulcate. Costellae measuring 3 to the millimeter at the anterior margin.

Pedicle valve gently convex in lateral profile; subcarinate in anterior profile with flat, moderately steep sides. Umbo and median region subcarinate, the fold continued to the anterior margin. Flanks bounding fold flat and moderately steep. Beak erect, gently incurved; interarea long and wide, apsacline. Interior with large teeth, stout but short dental plates; narrow and short muscle field.

Brachial valve gently convex in lateral profile and with the anterior quarter bent more or less strongly toward the pedicle valve; anterior profile broadly and gently convex but with the median region depressed. Umbo sulcate; sulcus widening and deepening anteriorly and forming a broad V. Flanks bounding sulcus very gently convex; posterolateral areas sloping gently. Interior with stout and moderately long brachiophores; brachiophore supports obscure; cardinal process variable, small; median ridge strong. Adductor pairs subequal.

Measurements in mm.—

| | | Length | Brachial length | Width | Hinge width | Thickness |
|----------|----------------|--------|-----------------|-------|-------------|-----------|
| Paratype | (117368h)..... | 8.2 | 7.5 | 9.1 | 6.9 | 4.0 |
| " | (117368i)..... | 8.1 | 7.6 | 8.5 | 7.1 | 4.1 |
| " | (117368j)..... | 7.8 | 7.4 | 7.7 | 7.1 | 3.9 |

Types.—Holotype: 117368b; figured paratypes: 117367a, 117368c-g, 123235a-d; unfigured paratypes: 117368a,h-j.

Horizon and locality.—Edinburg formation (low to middle *Nidulites* zone) in Strasburg (15') Quadrangle, Virginia: On U. S. Highway 11, 1 mile north of Strasburg; beside the road along Tumbling Run, 1½ miles southwest of Strasburg.

Siltstone in the Edinburg formation (Liberty Hall facies 30 feet above *Echino-sphaerites*) in Virginia: ¼ mile south of Virginia Highway 274, 1½ miles southwest of Wadesville, Winchester (15') Quadrangle.

Discussion.—This species is characterized by its squarish outline, fairly wide hinge, fine costellae, deep sulcus, and strong, subcarinate fold. Another common feature of this shell is that it develops strong plaits of growth at the anterior margin. This species differs from *P. matutina* in having finer costellae, deeper sulcus and more prominent fold, and a generally larger size.

EREMOTREMA Cooper, new genus

(Greek *eremo*, solitary; *trema*, opening)

Shells small, biconvex, subcircular to subquadrate, lateral margins rounded; anterior margin strongly rounded; anterior commissure rectimarginate; surface costellate, costellae fine, rounded, increasing by implantation in 4 generations. Punctate.

Pedicle valve somewhat deeper than the brachial valve, gently convex in profile; beak small, incurved; interarea long, nearly orthocline. Interior with thick, large teeth; delthyrial cavity deep and narrow; muscle area rhomboidal in outline; muscle scars deeply inserted, diductors long and narrow with their anterior ends approximate. Adductor track long and slender, obscure; pallial impressions

originating at anterior end of diductors, close and separated by a low, narrow median ridge. Dental plates obsolete.

Brachial valve moderately convex in both profiles; fairly strongly sulcate at the beak and umbo but sulcus nearly disappearing near the middle. Brachio-phores a stout blade with a poorly defined crus given off from the inner end; sockets deep; notothyrial cavity choked by excess shell supporting the inner sides of the brachio-phores; cardinal process with short, stout shaft and lobate myophore, the middle lobe of the myophore forming a high, narrow ridge. Median ridge low and stout, separating the small adductor scars.

Genotype.—*Eremotrema biconvexum* Cooper, new species.

Discussion.—This genus has obvious affinities with *Paucicrura* in the cardinalia of the brachial valve, but the shape, outline, and interior of the pedicle valve present important differences from that genus. *Eremotrema* is characterized by its subequally convex valves, long interareas on both valves, nonfasciculate costellae, rhomboidal muscle area, and stout, encrusted cardinalia.

Eremotrema differs from *Paucicrura* in the fairly strongly biconvex outline, that of *Paucicrura* being gently biconvex to planoconvex. The major difference is inside the pedicle valve, that of *Eremotrema* not having well-defined dental plates, ponderous teeth, and a muscle field with rhomboidal outline. The diductor scars in the muscle field are elongate and terminate with their anterior ends close together, which is quite unlike that of *Paucicrura* in which the anterior end of the muscle field is bilobate. The pallial trunks of *Eremotrema* are unlike those of *Paucicrura* but are suggestive of *Paurorthis* in being parallel and separated only by a low median ridge. The vascula media of *Paucicrura* are usually strongly divergent, not convergent as in *Eremotrema*.

Inside the brachial valve the cardinalia are like those of *Paucicrura* but are more exaggerated. Moreover, all the structures are thickened. The brachio-phores are supported by shell substance deposited on their inside. The cardinal process, unlike that in *Paucicrura*, protrudes from the notothyrium and projects beyond the margins of a long interarea.

EREMOTREMA BICONVEXUM Cooper, new species

Plate 146, G, figure 62; plate 160, E, figures 31-45

Subquadrate to subcircular in outline; sides gently rounded to nearly straight; widest just anterior to the middle; anterior margin broadly rounded; antero-lateral extremities narrowly rounded; anterior commissure rectimarginate. Valves subequally convex; surface costellate, costellae fine, rounded, separated by spaces equal in width to the width of the costellae; 3 costellae to the millimeter at the front margin and 4 costellae to the millimeter on the sides.

Pedicle valve gently convex in lateral profile; anterior profile with the median region elevated and long, moderately steep slopes to the margins. Beak small, well defined, incurved; umbo narrowly convex, forming a subcarinate fold that disappears at about the middle of the valve. Median region swollen; lateral slopes gently convex. Interarea nearly orthocline, gently curved, long; delthyrium long and narrow.

Brachial valve gently convex in lateral profile; anterior profile broadly convex, flattened in the median region and gently depressed at the middle; umbo sulcate; sulcus narrow but moderately deep, extending only to the valve middle; anterior slope long, moderately steep; median region somewhat swollen; lateral slopes short but moderately steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 11.3 | 10.1 | 11.1 | 9.0 | 5.2 |
| Paratype (117347a)... | 8.4 | 7.3 | 8.7 | 6.9 | 4.2 |

Types.—Holotype: 117350a; figured paratypes: 117347b, 117348a, 117349, 117350b,c; unfigured paratypes: 117347a, 117348b, 117350d,e.

Horizon and locality.—Benbolt formation (lower) in Virginia: On the south side of Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; east bank of sinkhole, 300 feet south of Lakeview Church on Virginia Highway 71, Moll Creek (T.V.A. 196-SE) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, 1½ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; ½ mile southeast of Richpatch, Eagle Rock (15') Quadrangle.

Discussion.—At present no other species of this genus is known with which *E. biconvexum* can be compared. The species is easily recognized by its form, fine costellae, thick valves, and ponderous cardinalia.

CRISTIFERINA Cooper, new genus

(Latin *crista*, crest; *fero*, bear)

Shell small, less than ½ inch in width, subelliptical to subcircular in outline; valves unequally convex, the brachial valve having less depth than the pedicle valve; anterior commissure gently sulcate; surface multicostellate, narrowly rounded, and strongly elevated, costellae increasing in number by intercalation.

Pedicle valve with stout teeth having large fossettes; dental plates short and stout; delthyrial cavity deep; muscle area heart shaped; diductor scars protruding anterior to the ends of the dental plates and forming 2 lobes at the front of the muscle field. Traces of somewhat divergent vascula media separated by a low median ridge appear in some specimens.

Brachial interior with moderately long bladeliike brachiophores having short, sharp crura protruding from their inner end; brachiophores supported by strong swelling of the notothyrial platform; sockets deep; no fulcral plates; cardinal process with short, grooved shaft, expanded myophore; surface of myophore with large, recurved median plate; median ridge strongly elevated. Adductor field small.

Genotype.—*Cristiferina cristata* Cooper, new species.

Discussion.—This genus is best recognized by its small size, strong costellae, deep pedicle valve and moderately convex brachial valve, and the character of the cardinalia, particularly the bizarre development of the cardinal process. As far as known the genus is rare.

The exterior of *Cristiferina* is strongly suggestive of *Paucicrura* of the Decorah

shale in the United States and of *Soudleyella* in the British sequence. It seems to be more strongly costellate than either of these two, and the interior of the brachial valve is different from that of both of them.

The pedicle interior of *Cristiferina* is not distinctly marked off from that of many other dalmanellids, but the brachial interior is distinctive. None of the specimens of the brachial interior shows a stage with fulcral plates although the brachiophores are very much like those of *Paucicrura*. An unusual feature of *Cristiferina* is the preservation of the crura. These are rarely seen structures in the punctate orthids, but they are well displayed as short, sharp points given off at an angle to the brachiophore. The crus protrudes from the inside end of the brachiophore.

The cardinal process of *Cristiferina* is the most distinctive feature of the genus, but it is quite variable. The shaft is short, usually stout and usually marked by a shallow median depression. The part of the cardinal process facing the interior of the pedicle valve is expanded laterally at the end of the shaft. The posterior face of the myophore thus forms a triangle. Down the center of this triangle extends a high, thin crest which divides the myophore. In lateral view this crest is notched just posterior to its junction with the myophore. Although some other dalmanellids have a crested myophore, none is developed to the degree seen in *Cristiferina*.

CRISTIFERINA CRISTATA Cooper, new species

Plate 157, E, figures 15-17; plate 157, G, figures 25-29; plate 158, C, figures 12-14;
plate 160, C, figures 16-28; plate 160, D, figures 29, 30

Subcircular in outline, sides and anterior margins well rounded; anterior margin gently sulcate; costellae numbering 2, rarely 3 to the millimeter at the front margin.

Pedicle valve fairly evenly and moderately convex in lateral profile; anterior profile strongly convex and with long, moderately steep slopes; beak moderately long, strongly incurved; umbo narrowly convex, the convexity extending to a point anterior to the middle but becoming vague thereafter; anterior slope short and steep; lateral slopes long and steep. Interarea moderately long, curved, apsacline. Delthyrium nearly plugged by the crest of the cardinal process.

Brachial valve gently and fairly evenly convex in lateral profile; anterior profile broadly and gently concave in the median region but with gently convex lateral areas; median region fairly strongly sulcate, the sulcus extending nearly to the anterior margin but becoming very shallow in its anterior limit. Flanks bounding sulcus gently swollen; lateral slopes short and gentle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 7.5 | 6.6 | 7.7 | 5.0 | 3.9 |
| Paratype (111794e)..... | 7.0 | 6.2 | 7.1 | 5.1 | 3.2 |
| " (111794h)..... | 9.3 | 8.5 | 9.1 | 6.5 | 4.3 |

Types.—Holotype: III794g; figured paratypes: III794b-d, II7351a,c, II7352n,o, II7353, II7354a,b; unfigured paratypes: III794a,e,f,h, II7351b,d-m; figured specimen: II7358a.

Horizon and locality.—Chatham Hill formation in Virginia: 1.2 miles S. 31° E. of Sharon Springs, Burkes Garden (15') Quadrangle; Grayson Farm, 4 miles southwest of Bland, Bland County.

Edinburg formation (*Cyrtototella* zone) in Virginia: $\frac{1}{2}$ mile west of Strasburg, Strasburg (15') Quadrangle.

Botetourt formation (*Cybeloides* zone) in Virginia: Opposite dam on North Fork of Shenandoah River, north side, 1.5 miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle.

Discussion.—This species is characterized by small size, strong costellae, and circular outline. It also represents a full development of the bizarre characters of the cardinal process. The species is one of the earliest known of the dalmanellid brachiopods on this continent. It differs from *C. cristifera* in its smaller size and more rotund form.

CRISTIFERINA CRISTIFERA Cooper, new species

Plate 158, B, figures 6-11; plate 159, C, figures 12, 13; plate 160, B, figures 11-15;
plate 161, D, figures 37, 38

Shell large for the genus, subcircular in outline; hinge moderately wide; greatest width at about the middle; sides gently rounded; anterior margin strongly rounded; anterior commissure gently sulcate. Costellae 2 or 3 to the millimeter at the anterior margin.

Pedicle valve fairly strongly convex in lateral profile; anterior profile strongly domed; umbo narrowly convex, the convexity broadening and finally disappearing toward the front margin; median region swollen; anterior slope convex, long, and steep; lateral slopes long and steep. Interarea moderately long, curved, apsacline. Dental plates short and thick; muscle field small, narrow; vascula media moderately developed.

Brachial valve gently convex in lateral profile; broadly and gently convex in anterior profile and with the median region depressed and the lateral slopes short and steep. Sulcus narrow and shallow, extending from umbo to anterior margin where it is shallowest. Flanks bounding sulcus slightly convex. Brachiphores short and thick; notothyrial cavity choked by a greatly thickened cardinal process with enormous median plate which fills the delthyrium.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 9.4 | 8.6 | 9.3 | 7.0 | 5.0 |
| Paratype (II7357a)... | 10.6 | 10.0 | 10.7 | 8.0 | 4.8 |

Types.—Holotype: II7356a; figured paratypes: II7355a, II7357b; figured specimen: II7358a; unfigured paratype: II7357a.

Horizon and locality.—Oranda formation in Virginia: On the Bowman Farm, about 1 mile southwest of the center of Woodstock and 0.3 mile east of U.S.

Highway 11, Edinburg (15') Quadrangle; opposite dam, North Fork of the Shenandoah River, $1\frac{1}{2}$ miles N. 61° E. of Edinburg, Edinburg (15') Quadrangle; U. S. Highway 11, $1\frac{1}{2}$ miles southwest of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This species has the large and prominent myophore crest of the genus, but is large and circular in outline. It is more finely costellate and larger than *C. cristata*, the only other known species of the genus. Tentatively referred here are some specimens occurring just under the Eureka quartzite in dark shales in Nevada on the north-facing nose of hill 8167, Martins Ridge, Roberts Mountains (1°) Quadrangle. This occurrence emphasizes the strong faunal relations between this shale and the Oranda formation of Virginia.

Genus **HOWELLITES** Bancroft, 1945

HOWELLITES sp.

Plate 145, E, figures 29, 30

Howellites BANCROFT, Journ. Paleont., vol. 19, No. 3, p. 203, 1945.

Figures of the exterior and interior of the brachial valve of *Howellites* are introduced for comparison with *Paucicrura*, *Cristiferina*, and *Eremotrema*.

Figured specimen.—83859a.

Horizon and locality.—Upper Ordovician (Soudleyan), Allt Fawr, Meifod District, Montgomeryshire, Wales.

Family PAURORTHIDAE Öpik, 1933

Dalmanellacea with a simple cardinal process, brachiophores simple and supported by notothyrial platform.

Genus **PAURORTHIS** Schuchert and Cooper, 1931

Paurorthis SCHUCHERT and COOPER, Journ. Paleont., vol. 10, No. 7, p. 243, 1931; Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 79, 1932.—ÖPIK, Acta et Comment. Univ. Tartu, ser. A, vol. 25, No. 1, p. 11, 1933.

PAURORTHIS CATAWBENSIS Butts

Plate 151, G, figures 30-36; plate 162, D, figures 19-23

Paurorthis catabensis BUTTS, Virginia Geol. Surv. Bull. 52, p. 67, pl. 80, figs. 11-13, 1942.

Shell of about average size for the genus, slightly wider than long with greatest width at about the middle. Cardinal extremities rounded. Lateral margins gently rounded, anterior margin narrowly rounded. Anterior commissure broadly sulcate. Surface multicostellate; costellae rounded, with very narrow interspaces. Fascicles low; about 5 costellae in the space of 1 mm. at the front.

Pedicle valve moderately convex with the greatest convexity located in the umbonal region when seen in lateral profile. Narrowly rounded in anterior profile. Fold obscure, defined as a longitudinal swelling extending from the beak

to the anterior margin. Lateral slopes moderately steep. Beak low; interarea short, strongly curved.

Brachial valve with the greatest convexity in the posterior half. Sulcus shallow, narrow at the umbo, widening anteriorly, but never conspicuous. Anterior profile very gently convex; areas bounding the sulcus very gently swollen. Slopes to cardinal extremities gently concave, moderately steep.

Interior of pedicle valve with a subcordate muscle field; diductor and adductor tracks subequal; median ridge low and short. Brachial valve with short, stout brachiophores, narrow and deep notothyrial cavity, and rudimentary cardinal process.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------------------|--------|-----------------|-------|-------------|-----------|
| Lectotype (brachial valve) | ? | 7.5 | 9.2 | 7.0 ? | ? |
| Hypotype (pedicle valve 117276a).... | 7.3 | ? | 10.0 | 8.0 ? | ? |
| “ (“ “ 117276g).... | 8.6 | ? | 10.3 | 8.0 ? | ? |
| “ (brachial valve 117276b)... | ? | 8.5 | 9.4 | 6.0 ? | ? |
| “ (117277c) | 6.9 | 6.6 | 9.0 | 6.5 | 4.2 |

Types.—Lectotype: 99259c; paratypes: 99259a,b; figured hypotypes: 117275, 117276a-e; 117277d, 117278a,b; unfigured hypotypes: 117276f,g, 117277a-c.

Horizon and locality.—Botetourt formation in Virginia: At the junction of Virginia Highways 311 and 114, ½ mile southwest of Catawba, Salem (15') Quadrangle; junction of Virginia Highways 731 and 724, 2 miles northwest of Brownsburg, Lexington (15') Quadrangle; south side of the road 0.2 mile east of Strasburg Junction, Strasburg (15') Quadrangle.

Arline formation in Virginia: In the quarry at Marion, Marion (T.V.A. 218-SE) Quadrangle.

Blockhouse formation in Tennessee: 1.6 miles south-southwest of Toqua School, Vonore (T.V.A. 139-SE) Quadrangle.

Discussion.—The types of this species are impressions of the inner and outer surfaces in a soft shale. The species is characterized by a roundly elliptical outline but with distinct shoulders in the posterior region. Costellae and fascicles are fine and crowded. It is not so strongly fasciculate as the Friendsville and Little Oak species. It is somewhat more finely costellate and with less prominent fascicles than *P. macrodeltoidea* from the Bromide formation. It is not so strongly sulcate as *P. spinosa* from the Edinburg formation.

PAURORTHIS FASCICULATA Cooper, new species

Plate 150, B, figures 17-24; plate 151, C, figures 12-18; plate 155, B, figures 11-13
Deltatrete elegantula BUTTS (part), Alabama Geol. Surv., Special Rep. 14, pl. 18, fig. 27, 1926.

Shell of about medium size for the genus, with both valves strongly convex and the hinge equal to about seven-tenths the width. Cardinal extremities obtuse. Length and width subequal. Lateral margins moderately well rounded; anterior margin broadly rounded. Surface fascicostellate with the costellae bundled into a number of well-defined and elevated fascicles; 2 fascicles occupy the sulcus of

the brachial valve, and 2 strong fascicles bound the sulcus. Median fascicle of the pedicle valve forming a low fold; 4 distinct fascicles present on the lateral slopes flanking the median fascicle.

Pedicle valve moderately convex in lateral profile with the maximum convexity located near the middle. Anterior profile narrowly rounded and with steep lateral slopes. Interarea apsacline, curved; beak incurved.

Brachial valve moderately convex in lateral profile; gently convex in anterior profile and with the center slightly depressed at the sulcus. Sulcus originating at the umbo, deepest near the middle and becoming broad and shallow at the anterior. Flanks bounding sulcus slightly swollen. Slopes to the cardinal extremities steep, slightly concave. Interarea moderately long, gently curved.

Interior of pedicle valve with fairly well developed vascula media but poorly defined median elevation. Median ridge of brachial valve low; cardinal process not preserved, or rudimentary.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|--------------------|-------|----------------|-----------|
| Holotype | 8.0 | 7.7 | 9.6 | 6.9 | 4.8 |
| Paratype (117279a).... | 9.6 | 8.9 | 10.6 | 8.6 | 6.8 |

Types.—Holotype: 117280a; figured paratypes: 117279a, 117280b,g; unfigured paratypes: 117279b-e, 117280c-f.

Horizon and locality.—Little Oak formation in Alabama: At the intersection of the Bailey Gap and Cahaba Valley roads, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle; 1 mile northeast of Pelham, 2 miles north of Pelham, on the west side of U. S. Highway 31, $\frac{1}{2}$ mile north-northeast of Pelham, Bessemer Iron District (15') Quadrangle.

Arline formation (middle) in Tennessee: On north side of wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Tellico formation in Tennessee: On Chapman Highway (Tennessee 71), 1.3 miles east-northeast of Cusick, Walden Creek (T.V.A. 156-SW) Quadrangle; BM-LHT 1366, 1 mile southeast of Chilhowee View School, Blockhouse (T.V.A. 148-NW) Quadrangle.

Discussion.—This species is characterized by the strength of the fasciculation of its costellae. The fascicles are more regularly developed than in any other species described herein.

PAURORTHIS FASCIFERA Cooper, new species

Plate 149, D, figures 26-29

Shell small, wider than long, with the greatest width slightly posterior to the middle. Sides gently rounded; anterior margin somewhat narrowly rounded; anterior commissure gently sulcate; fascicostellate, fascicles strong and prominent, generally consisting of 3 costellae.

Pedicle valve gently convex in lateral profile with the greatest depth just anterior to the umbo; anterior profile narrowly convex in the median region with

long, steep slopes. Median region folded medianly. Beak narrow, strongly incurved. Interarea curved, steeply apsacline.

Brachial valve evenly and moderately convex in lateral profile, broadly and gently convex in anterior profile. Sulcus broad and shallow; flanks gently inflated, with short and moderately steep slopes.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 7.2 | 6.7 | 8.1 | 6.0 | 4.5 |
| Paratype (117281b)..... | 7.6 | 7.2 | 9.0 | 7.2 | 4.2 |
| " (117281c)..... | 6.8 | 6.5 | 7.9 | 6.4 | 3.9 |

Types.—Holotype: 117281a; unfigured paratypes: 117281b-d.

Horizon and locality.—Ward Cove formation in Fountain City (T.V.A. 146-SW) Quadrangle, Tenn.: Inskip, military coordinates E-2, 604, 600-700/N596, 350; Hickey place, 2 miles southwest of Hall Crossroad.

Discussion.—This is a rare species and is known only from a few silicified specimens. It is strongly fasciculate, but the fascicles are narrower than those of *P. fasciculata*. The species is more strongly sulcate and more strongly fasciculate than *P. catwambensis*.

PAURORTHIS GIGANTEA Cooper, new species

Plate 269, F, figures 25-31

Large for the genus, subcircular in outline with the length and width nearly equal; sides rounded; anterior margin rounded; hinge narrow, in width about two-thirds the length. Anterior commissure gently sulcate. Surface fascicostellate, fascicles low, generally best defined near the valve middle. Costellae fine, rounded, closely crowded, numbering 4 or 5 in 1 mm. at the front margin of an adult.

Pedicle valve unevenly convex in lateral profile, the maximum curvature being located in the umbonal region and the anterior two-thirds gently convex; anterior profile strongly domed. Median region from umbo to anterior margin somewhat swollen to form an ill-defined fold; flanks gently swollen and steep. Interarea long, curved; beak strongly incurved. Interior with deep delthyrial cavity and prominent median ridge anterior to it.

Brachial valve less convex than the pedicle valve, gently convex in lateral profile with the maximum convexity in the posterior third; anterior profile broadly and gently convex. Anterior half flattened and bearing a poorly defined shallow sulcus. Flanks gently swollen. Interarea long and curved. Interior unknown.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | 19.0 | 17.8 | 18.2 | 13.1 | 11.1 |
| Paratype (124235b)..... | 16.9 | 15.8 | 17.0 | 11.1 | 9.0 |

Types.—Holotype: 124235a; figured paratype: 124235c; unfigured paratypes: 124235b, d-f.

Horizon and locality.—Dark shale below the Eureka quartzite in Nevada: Below two knobs of the Eureka quartzite, north side canyon, 3.1 miles N. 32° E. of Blair (Segura) Ranch, Antelope Mountains, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by its large size and fine costellae. The only other American *Paurorthis* approaching it is *P. ponderosa* from the Benbolt formation, but this does not attain the size of the western species. Furthermore, *P. ponderosa* has narrower fascicles and a more carinate pedicle valve than *P. gigantea*.

PAURORTHIS LONGA Cooper, new species

Plate 150, A, figures 1-16

Small, subrectangular in outline, with the length and width about equal; greatest width at about the middle; sides nearly straight; anterolateral extremities narrowly rounded; anterior margin rounded. Hinge narrower than the greatest shell width. Anterior commissure sulcate. Surface fascicostellate.

Pedicle valve gently convex in lateral profile; strongly convex in anterior profile and much deeper than the brachial valve; beak long, incurved; interarea curved, moderately apsacline. Umbo and median region swollen from beak to anterior margin and thus forming a fold; flanks gently inflated, steep.

Brachial valve moderately convex in lateral profile and with the maximum depth in the posterior two-thirds; anterior third gradually geniculated toward the pedicle valve; anterior profile broadly convex, with middle slightly concave. Umbo and region immediately anterior to it strongly swollen; sulcus originating at the beak, broad and shallow. Flanks full and with moderately steep slopes.

Interior of brachial valve with delthyrial cavity deep and long, dental plates nearly obsolete; median ridge well developed, usually narrow and extending nearly to the anterior margin. Delthyrium narrowed by lateral plates.

Brachial interior with thick brachiophores, prominent median ridge, and deeply impressed adductor impressions.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.3 | 7.2 | 7.7 | 6.6 | 5.4 |
| Paratype (117282a)..... | 7.7 | 6.9 | 7.6 | 6.2 | 5.1 |
| " (117282c)..... | 8.4 | 7.2 | 8.1 | 6.7 | 5.0 |

Types.—Holotype: 117282b; figured paratypes: 117282a,c,e-k, 117283d; unfigured paratypes: 117282d, 117283a-c,e.

Horizon and locality.—Lower part of Arline formation in Tennessee: 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville; $\frac{3}{4}$ mile east-southeast of Friendsville; north side wagon road in glade, $\frac{1}{4}$ mile southeast of Friendsville; Concord (T.V.A. 138-SW) Quadrangle.

Discussion.—This species is related to *P. fasciculata* but is distinguished by a thick shell and an elongate form. The sides are subparallel, and the fasciculation is less regular than in *P. fasciculata*.

PAURORTHIS MACRODELTOIDEA Cooper, new species

Plate 151, A, figures 1-6

Shell of about average size for the genus; hinge equal to about three-quarters the width. Lateral margins well rounded, anterior margin broadly rounded. Anterior margin sulcate. Surface fascicostellate, fascicles numerous but not well defined. About 4 costellae in 1 mm. at the front margin.

Pedicle valve strongly swollen longitudinally to form an indistinct median fold and giving the valve a subcarinate anterior profile. Slopes from the median fold to the margin steep. Fullness of pedicle valve extended to the front margin, although the convexity in the anterior portion is not so great as that in the umbonal region. Interarea only moderately curved. Delthyrium partially closed by lateral plates.

Brachial valve most convex in the umbonal region and posterior half; anterior half somewhat depressed and anterior margin slightly extended at the sulcus to form a short tongue. Sulcus originating at the umbo, shallow but widening and deepening anteriorly. Flanks bounding sulcus gently swollen; slopes to cardinal extremities slightly concave, moderately steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 10.0 | 8.8 | 10.6 | 7.0 ? | 5.0 |
| Paratype (117284b).... | 9.7 ? | 8.6 | 10.4 | 7.8 ? | 5.8 |
| " (117285)..... | 9.2 ? | 8.4 | 10.4 | 8.0 | 5.4 |

Types.—Holotype: 117284a; figured paratype: 117285; unfigured paratypes: 117284b-g.

Horizon and locality.—Bronide formation (Pooleville member) in Murray County, Oklahoma: Zone 13, 241 feet below Viola, Spring Creek, east of Pooleville, sec. 17, T. 2 S., R. 1 W.; West Spring Creek, sec. 6, T. 2 S., R. 1 W.

Discussion.—The occurrence of this genus in the Simpson sequence is interesting because it is a link to the Southern Appalachians. The species is similar to *P. catawbensis* and *P. fasciculata* of the Southern Appalachians but differs in having stronger costellae than the former and less regular fasciculation than the latter.

PAURORTHIS MAGNA Cooper, new species

Plate 149, C, figures 10-25; plate 149, E, figures 30-33; plate 149, F, figures 34-43

Shell large for the genus, slightly wider than long, valves strongly convex, and hinge equal to a little less than three-quarters the width at the middle. Cardinal extremities well rounded. Lateral and anterior margins broadly rounded. Anterior commissure broadly sulcate. Surface fascicostellate, fascicles consisting of 5 to 7 costellae. Fascicles not strongly elevated, a deep, narrow groove extending from the umbo of the brachial valve to the front margin. On the pedicle valve this groove represented by a costella stronger than those surrounding it.

Pedicle valve moderately convex in lateral profile with the greatest convexity

in the vicinity of the umbo; anterior profile broadly and moderately convex. Fold represented by a gentle longitudinal swelling from the umbo to the front margin. Lateral slopes flat and moderately steep. Interarea short and strongly incurved. Beak low, incurved.

Brachial valve with the greatest convexity at the umbo in lateral profile; anterior profile moderately convex but with a shallow depression in the medial region. Sulcus shallow and broad, originating at the umbo but becoming indistinct at the front of old shells. Posterior half of shell moderately swollen, anterior half depressed. Flanks bounding sulcus gently swollen. Lateral slopes short, slightly concave and moderately inclined.

Interior of pedicle valve with muscle field usual for the genus but much thickened at the front margin and with a thick callosity tapering anteriorly from the margin. Adductor track thickened and elevated. Brachial interior with unusually long brachioophores, cardinal process ranging from a thin septum to a thick boss, and moderately elevated median ridge.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.2 | 10.9 | 13.8 | 9.9 | 5.9 |
| Paratype (117286q) ... | 12.2 | 11.2 | 13.8 | 9.4 ? | 6.5 |
| “ (117291b) ... | 12.5 | 11.3 | 13.1 | 9.6 | 7.8 |
| “ (117291a) ... | 11.6+ | 10.7 | 13.4 | 10.9 | 6.9 |
| “ (117292b) ... | 11.7 | 11.2 | 12.4 | 9.1 | 6.0 |

Types.—Holotype: 117287b; figured paratypes: 117286a-c,q, 117287a, 117288, 117289a, 117291a,b, 117292a-c (d missing); unfigured paratypes: 117286d-p, 117289b, 117291c.

Horizon and locality.—Lincolnshire formation in Tennessee: $\frac{1}{2}$ mile northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle; in Clinch Valley at Shiloh Church near center northwest subquad., Pressmens Home (T.V.A. 171-NE) Quadrangle.

Same formation in Virginia: Along Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg, Strasburg (15') Quadrangle.

Lincolnshire formation (Hogskin member) in Tennessee: Sally Cleveland Farm $\frac{3}{4}$ mile southwest of Washburn, Dutch Valley (T.V.A. 154-SE) Quadrangle; 0.4 mile east-northeast of Red Hill, 4 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; road to Washburn 3 miles west-southwest of Thorn Hill, Avondale (T.V.A. 162-SW) Quadrangle; $\frac{1}{2}$ mile north and northwest of Eidson, Kyles Ford (T.V.A. 170-SE) Quadrangle.

Discussion.—This species attains an unusually large size for the genus but is not the largest of the species known in the Appalachians. Its shape is somewhat variable, but in general it is not so circular as *P. ponderosa*. The latter form is a much thicker shelled species and attains a much larger size. The fascicles of the Lincolnshire species are smaller and less prominent than those of *P. ponderosa*. Young specimens of *P. magna* are suggestive of *P. catawbensis* but have rounded sides and a more broadly rounded anterior margin.

The interior of *P. magna* is also quite distinctive. The adductor track in the

delthyrial cavity is often very strongly elevated, and a small median ridge extends anteriorly from it. The brachio-phores of the brachial valve are unusually long, and some of them show crura extending from the anterior end on the side nearest the brachial valve.

PAURORTHIS PARVA (Pander)

Plate 151, D, figure 19

The brachial interior of the European species is introduced for comparison with American shells. This is the type species of the genus.

Figured specimen.—52314h.

Horizon and locality.—Walchow formation (BII), in Russia: Near Leningrad.

PAURORTHIS PONDEROSA Cooper, new species

Plate 146, E, figures 39-43; plate 149, G, figures 44-53; plate 151, F, figures 25-29

Large for the genus, thick shelled, subcircular in outline; greatest width at the middle; cardinal extremities rounded; sides gently rounded; anterior margin somewhat narrowly rounded. Anterior commissure broadly and moderately deeply sulcate. Hinge width one-third less than the midwidth. Surface fascicostellate, the fascicles best developed in the younger stages, flattening and dissolving near the anterior margin.

Pedicle valve moderately convex in lateral profile, with the greatest convexity just anterior to the umbo; anterior profile strongly and somewhat narrowly convex and with long, steep lateral slopes. Pedicle valve deeper than the brachial valve. Beak long and incurved; interarea gently apsacline, curved. Umbonal and median regions narrowly swollen to form a fold with steep sides.

Brachial valve in lateral profile most convex in the posterior two-thirds, somewhat flattened in the anterior third. Anterior profile moderately and broadly convex and with a slight median depression. Umbonal region strongly swollen; beak prominent. Sulcus originating at the beak, shallow throughout its extent. Flanks gently inflated; slopes to the margins short, moderately steep.

Interior of pedicle valve with deep and wide delthyrial cavity, deeply impressed vascula media separated by a narrow and low median ridge. Brachial interior with narrow and shallow notothyrial cavity and short, stout brachio-phores.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|----------------------------------|--------|--------------------|-------|----------------|-----------|
| Holotype | 13.7 | 12.4 | 13.6 | 10.2 | 9.3 |
| Paratype (117296a) | 11.7 | 11.2 | 12.3 | 9.1 | 6.8 |
| “ (117294b) | 12.2 | 11.1 | 11.9 | 9.9 | 7.4 |
| “ (pedicle valve 117295a) | 15.3 | ? | 15.7 | 10.7 ? | 6.7 |
| “ (brachial valve 117295b) | ? | 15.1 | 15.6 | 10.2 | 3.6 |

Types.—Holotype: 117294a; figured paratypes: 117293, 117294b, 117295a,b, 117296a; unfigured paratypes: 117296b.

Horizon and locality.—Sevier formation (near base) in Tennessee: On the

east side of the road 0.2 mile north-northwest of Gooseneck, Louisville (T.V.A. 138-SE) Quadrangle.

Benbolt formation in Virginia: At Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle; 0.2 mile south of the middle fork of Moccasin Creek, 1½ miles due south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle; ¼ mile east of Speers Ferry, Clinchport (T.V.A. 188-NW) Quadrangle; south side of Moccasin Creek, 1.2 miles east-northeast of Willow Spring, Hansonville (T.V.A. 205-SW) Quadrangle; west slope of hill ½ mile east of Cedar Point School, Hilton (T.V.A. 197-NW) Quadrangle; south side of Mount Hagan School, Hilton (T.V.A. 197-NW) Quadrangle; east bank of sinkhole 300 feet south of Lakeview Church on Virginia Highway 71, southwest quarter east central subquad., Moll Creek (T.V.A. 196-SE) Quadrangle; on Virginia Highway 74, 5½ miles east-northeast of the junction with U. S. Highway 54 (=Virginia Highway 71), Hilton (T.V.A. 197-NW) Quadrangle.

Shippensburg formation (Pinesburg member-*Echinosphaerites* zone) in Maryland: On U. S. Highway 40 on the west side of Conococheague Creek, 7 miles west of Hagerstown, Williamsport (15') Quadrangle.

Discussion.—This is the largest species of this genus in the eastern United States. It is characterized by thick shells having a nearly circular outline or somewhat longer than wide. The fasciculation is strong but fine. The species differs from *P. magna*, the only other *Paurorthis* approaching *P. ponderosa* in size, by its stronger fasciculation, more circular form, and thick shells. Young specimens are also robust and subcircular. They are suggestive of *P. catawbensis* but are more robust.

PAURORTHIS SPINOSA Cooper, new species

Plate 151, E, figures 20-24

Shell of about medium size for the genus, slightly wider than long, with rounded sides and anterior margin. Hinge narrower than the greatest shell width which is at the middle; anterior commissure sulcate. Fascicostellate, fascicles narrow, generally consisting of 2 to 3 costellae. Costellae in median and anteromedian areas with short, spiny projections.

Pedicle valve fairly evenly and strongly convex in lateral profile; anterior profile somewhat narrowly convex in the median region but with long, moderately steep slopes. Beak strongly incurved; interarea gently apsacline, strongly curved. Umbo narrowly swollen, the swelling passing anteriorly into the inflated median region. Flanks slightly convex in profile, moderately steeply inclined.

Brachial valve fairly evenly and gently convex in lateral profile; anterior profile broadly and gently convex. Beak prominent, umbo swollen. Sulcus originating at the beak, narrow and fairly deep at its place of origin but becoming wider and shallower anteriorly. Flanks moderately and narrowly swollen; lateral slopes short and moderately steep.

Measurements in mm.—Holotype, length 8.5, brachial length 7.7, width 9.2, hinge width 7.0, thickness 5.4.

Type.—Holotype: 117297.

Horizon and locality.—Edinburg formation (about middle of *Nidulites* zone) in Virginia: On Tumbling Run, $1\frac{1}{2}$ miles southwest of Strasburg, Strasburg (15') Quadrangle.

Discussion.—This is a small shell but a distinctive one. It is characterized by somewhat distant costellae which form indistinct and narrow fascicles. The pedicle valve is somewhat narrowly convex in anterior profile, and the sulcus on the brachial valve is deep. It differs from *P. catarwensis* in ornamentation and form; it differs from *P. fasciculata* and *P. fascifera* in its more distant costellae and finer fascicles; it is not parallel sided like *P. longa*, and it differs from young forms of *P. magna* and *ponderosa* in its distant costellae and lesser fasciculation. It has a strong development of short, spiny projections particularly on the brachial valve. These were seen in other species but not in the degree to which they are developed on this one.

PAURORTHIS sp. 1

Plate 150, C, figures 25-37

Shell of about medium size for the genus, subcircular in outline; relation of length and width variable, some specimens having width greater than length and vice versa. Greatest width at about the middle; margins strongly rounded; anterior commissure gently sulcate. Surface fascicostellate; fascicles narrow, numerous, and consisting of 3 or 4 costellae.

Pedicle valve unevenly convex in lateral profile, with the maximum curvature just anterior to the umbo; anterior profile narrowly convex and with steep lateral slopes. Beak long; interarea curved, gently apsacline. Umbo swollen; median area just posterior to middle strongly swollen. Anterior moderately swollen; lateral slopes flat and steep.

Brachial valve with maximum convexity just posterior to the middle; anterior profile broadly convex and with the median region slightly indented by the sulcus. Beak prominent, umbo moderately swollen; sulcus originating at the beak, shallow and wide, merging anteriorly into the flattened anterior. Sulcus occupied anteriorly by 3 to 5 fascicles. Flanks gently swollen; lateral slopes steep.

Interior of pedicle valve with deep notothyrial cavity; dental plates obsolete. Vascula media prominent and separated anteriorly by a short, low thickening of the floor; diductor scars usually distinct, elongate, but often not impressed in old and thick shells.

Brachial interior with thin cardinal process, thick brachioophores, and low median ridge. Adductor field deeply impressed, elongate.

Measurements in mm.—117299a, length 9.8, brachial length 8.5, width 10.5, hinge width 7.4, thickness 5.7.

Figured specimens.—117298a-e, 117299a.

Horizon and locality.—Basal Athens formation in Tennessee: 600 feet S. 40° E. of the railroad crossing 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-NE) Quadrangle; roadside just east of intersection $2\frac{1}{2}$ miles south-southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle.

Discussion.—The specimens described above suggest *P. longa* and *P. fasciculata*. They differ from the former in not having the strongly parallel sides and from the latter in not being so strongly fasciculate. They are nearer the latter, however.

PAURORTHIS sp. 2

Plate 151, B, figures 7-11

Shell of about medium size, wider than long with narrowly rounded cardinal extremities, nearly straight sides and broadly rounded anterior margin. Anterior commissure somewhat narrowly sulcate. Surface fascicostellate, fascicles crowded, consisting generally of 2 or 3 costellae.

Pedicle valve moderately convex in lateral profile and with the greatest curvature just anterior to the umbo; anterior profile narrowly convex in the middle, with long and moderately steep lateral slopes. Beak long, strongly incurved; interarea short, apsacline. Umbo subcarinate, the carination continued anteriorly as an indistinct fold nearly to the front margin. Lateral slopes slightly convex.

Brachial valve gently and evenly convex in lateral profile; anterior profile gently and broadly convex and with the median region slightly depressed. Sulcus originating at the beak, moderately deep and wide at the anterior margin. Flanks gently swollen; lateral slopes fairly long and gentle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------|--------|-----------------|-------|-------------|-----------|
| 117302a..... | 8.0 | 7.4 | 9.0 | 7.2 | 4.7 |
| 117302b..... | 7.6 | 7.2 | 9.0 | 7.3 | 4.3 |

Figured specimen.—117302a; unfigured specimen: 117302b.

Horizon and locality.—Lower part of Sevier formation in Tennessee: $\frac{1}{2}$ mile northeast of Miser, Louisville (T.V.A. 138-SE) Quadrangle.

Discussion.—These shells suggest *P. catarwbcnsis* in outline and the somewhat shouldered character of the posterior half. They are, however, more deeply sulcate and have a more erect beak.

CYCLOMYONIA Cooper, new genus

(Greek *kyklas*, circle; *mys*, muscle)

Shell small, dalmanellid in outline and profile; pedicle valve deeper than the brachial valve. Anterior commissure gently sulcate. Surface finely costellate, the costellae not markedly fasciculate. Punctate.

Pedicle interior with small, long teeth; dental plates fairly strong, receding and forming a rim to the muscle area. Delthyrial cavity deep, generally with the floor thickened and occupied by a wide adductor track; diductor scars small and narrow. Anterior to delthyrial cavity floor of valve occupied by a short, elevated callosity. Vascula media strong, located on each side of callosity.

Brachial valve like *Paurorthis* with small notothyrial chamber occupied by a simple cardinal process; fairly long brachiophores. Median ridge long and narrow. Adductor field somewhat shield shaped, the posterior adductors lying out-

side the elongate anterior pair which is located on each side of the median ridge.

Genotype.—*Cyclomyonia peculiaris* Cooper, new species.

Discussion.—This genus strongly resembles *Paurorthis* in its external form and brachial interior but differs in ornamentation, the small teeth of the pedicle valve, the strong callosity anterior to the pedicle muscle area, and the greater development of the dental plates.

This genus was individualized because of the peculiarities of the interior of the pedicle valve and variations of the exterior from typical *Paurorthis*. The ornamentation of *Cyclomyonia* is more even and is not so strongly fasciculate as that of *Paurorthis*. Inside the brachial valve the apex is marked in some specimens by a thickening in the form of a narrow fold bent toward the floor and leaving a crease in the middle. This is like a thickening seen in other punctate shells.

The teeth are long and slender and quite suggestive of *Laticrura*. The dental plates are of the receding type, forming a rim along the delthyrial edge and the side of the delthyrial cavity. These swing toward the floor and unite with the marked callosity anterior to the delthyrial cavity. This callosity is not like the thickening seen in *Paurorthis* which is usually a long, slender ridge extending nearly to the anterior margin. In some specimens of *Cyclomyonia* the vascula media are curved at the anterolateral extremity of the callosity.

CYCLOMYONIA PECULIARIS Cooper, new species

Plate 146, F, figures 44-61

Shells approaching $\frac{1}{2}$ inch in width, wider than long; sides and anterior margin rounded; greatest width at about the middle. Surface marked by fine costellae, about 5 to the millimeter at the anterior margin.

Pedicle valve deeper than the brachial valve and having a moderately strongly convex lateral profile; anterior profile somewhat narrowly convex in the median region and with long, steep lateral slopes. Interarea long, strongly apsacline; beak incurved. Umbo swollen and subcarinate, the swelling continued anteriorly at least to the middle where it merges into the general convexity. Median region swollen; flanks gently convex.

Brachial valve most convex in the posterior third when seen in lateral profile; anterior profile gently and broadly convex but with a median depression. Sulcus originating at the beak, shallow, but with the median line deepest. Flanks somewhat swollen.

Measurements in mm.—Holotype, length 7.8, width 9.2, hinge width 7.6, thickness 3.0.

Types.—Holotype: 117300c; figured paratypes: 117300a,b,d-j.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species of this genus is now known to which this species can be compared.

Family HETERORTHIDAE Schuchert and Cooper, 1931

Subfamily HARKNESSELLINAE Bancroft, 1928

Biconvex, fascicostellate Heterorthidae having a prominent fold on the pedicle valve and a corresponding sulcus on the brachial valve.

Genus REUSCHELLA Bancroft, 1928

Reuschella BANCROFT, Mem. Manchester Lit. Phil. Soc., vol. 72, p. 180, 1928.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 139, 1932.

This genus embraces large shells externally fascicostellate and with endopunctate shell structure. The pedicle valve generally bears a prominent median fold and the brachial valve is strongly sulcate. The valves are subequally convex. Inside the pedicle valve the muscle field is small with the adductor field occupying a shallow depression and the diductor tracks located on each side of it. The dental plates are generally short but stout. Inside the brachial valve the brachio-phores are short and stout and are supported by swelling of shell substance along their inner surfaces. The cardinal process has a short shaft borne on the swelling that clogs the notothyrial cavity; the myophore is small and trilobate. The median ridge is short and low.

This genus is fairly common in the Middle Ordovician of England and Wales but has hitherto not been reported on this continent. It proves now to be common in the Oranda formation in Virginia and is known from the Trenton (Sherman Fall) in Vermont. A species has been identified in the Jacksonburg formation of New Jersey, and another is known from dark shales under the Eureka quartzite in Nevada.

REUSCHELLA AMERICANA Cooper, new species

Plate 147, A, figures 1-7; plate 147, B, figures 8-20

Dalmanella cdsoni BASSLER (part), Cambrian and Ordovician: Maryland Geol. Surv., p. 243, pl. 49, figs. 17-19 (not 20 and 21), 1919.—COOPER and COOPER, Bull. Geol. Soc. Amer., vol. 57, pl. 3, figs. 33, 34, 1946.

Shell large, rectangular in outline with the width slightly greater than the length. Cardinal extremities varying from acute to obtuse; lateral margins slightly concave to gently rounded; anterolateral extremities somewhat narrowly rounded; anterior margin truncated. Anterior commissure rectimarginate to sulcate. Surface fascicostellate with 5 or 6 well-defined fascicles on each side of the fold. Fold consisting of 3 fascicles, a median one and one on each side of it. Costellae appearing in 4 generations by bifurcation and intercalation; 7 to 10 costellae may be counted in 5 mm. at the front margin.

Pedicle valve gently convex in lateral profile with the greatest convexity in the posterior half. Fold originating at the beak where it is very narrowly rounded and generally smooth, widening gradually anteriorly and heightening to about the middle from which it gradually declines in height to the front margin. Fold scarcely distinguishable at the front margin of some specimens except for the

bundling of costellae. Lateral slopes of fold steep; flanks bounding fold flattened or gently concave, becoming gently convex in a posterolateral direction where the areas just anterior to the cardinal extremities are gently convex. Slopes to cardinal extremities gentle. Interarea short, apsacline.

Brachial valve very gently convex with the greatest convexity in the posterior half; about as deep as the pedicle valve. Sulcus narrow and deep in the posterior third, becoming wider and shallower anteriorly to the front margin where it occupies about one-quarter the valve width. Folds bounding sulcus strongest in the posterior, becoming flatter anteriorly and almost disappearing along the anterolateral margin. Slopes to lateral margins gentle.

Pedicle interior having small muscle field with width about equal to length; teeth small; dental plates short, stout. Median ridge inside the brachial valve heightened by the exterior sulcation which is most prominent at the posterior. Notothyrial cavity much restricted by secondary shell built on the inner sides of the short brachioophores; cardinal process short and stout.

Measurements in mm.—

| | Length | Width | Hinge width | Thick- ness |
|--|--------|-------|-------------|----------------|
| Holotype | 25.0 | 31.8 | 32.3 | ? |
| Paratype (pedicle valve 110840m) | 13.3 | 17.8 | 17.3 | ? |
| “ (“ “ 110840e) | 21.8 | 28.4 | 28.7 | ? |
| “ (“ “ 110840a) | 21.7 | 27.3 | 27.3 | ? |
| “ (brachial valve 110840k) | 12.8 | 16.5 | ? | ? |
| “ (“ “ 110840h) | 21.4 | 28.8 | 25.0 ? | ? |
| “ (“ “ 110840f) | 25.5 | 34.1 | 28.6 | ? |

Types.—Holotype: 110840b; figured paratypes: 110840a, c-g, i, w; unfigured paratypes: 110840h, j-v; figured specimens: 117346a-e.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville Station; just west of the junction of Virginia County Highways 617=910, and 777 about $\frac{1}{4}$ mile north of Green Mount Church, Broadway (15') Quadrangle.

Bowman Farm, south side of U. S. Highway 11, 1 mile southwest of Woodstock, Edinburg (15') Quadrangle; Cedar Grove Church, 200 yards on Virginia County Road 616, 3.5 miles southwest of Mount Jackson, Mount Jackson (15') Quadrangle; on U. S. Highway 11, $1\frac{1}{2}$ to 2 miles southwest of Strasburg, Strasburg (15') Quadrangle; 3 miles north of Long Glade=Spring Hill, Parnassus (15') Quadrangle.

Same formation in Pennsylvania: 1 mile south of St. Thomas, Mercersburg (15') Quadrangle.

Jacksonburg formation in New Jersey: $1\frac{1}{2}$ miles south of Annandale, Hunterdon County.

Discussion.—This species is characterized by its narrow fold and sulcus, large size, and fasciculate exterior. It is distinguished from *R. edsoni* in the less prominent development of the fold and sulcus.

REUSCHELLA EDSONI (Bassler)

Plate 148, D, figures 27-29

Dalmanella edsoni BASSLER, Cambrian and Ordovician: Maryland Geol. Surv., p. 243, pl. 49, figs. 20, 21 (not 17-19 = *Reuschella americana* Ulrich and Cooper), 1919.—KAY, Bull. Geol. Soc. Amer., vol. 48, p. 302, pl. 10, 1937.

Large, slightly wider than long, cardinal extremities acute or obtuse depending on width of hinge; lateral margins gently rounded; front margin truncated. Anterior commissure strongly sulcate. Surface fascicostellate.

Pedicle valve marked by a prominent subcarinate median fold that increases in height to the middle or slightly anterior to the middle, after which it slopes to the anterior margin. Slopes flanking fold long and moderately steep. Areas bounding fold gently convex. Inside the pedicle valve the muscle field is fairly large, in length about equal to one-tenth the length of the valve. Width of muscle field about equal to its length. Diductor scars large.

Brachial valve gently convex in lateral profile, with the greatest convexity at about the middle. Sulcus prominent, widening and deepening anteriorly to the front margin where it occupies slightly more than a third of the width of the valve. Folds bounding sulcus gently convex with gentle slopes to the cardinal and lateral margins. Interior unknown.

Measurements in mm.—

| | Length | Width | Hinge width |
|---------------------------------------|--------|-------|-------------|
| Lectotype (pedicle valve)..... | 24.9 | 29.4 | 34.0 |
| Paratype (brachial valve 66169b)..... | 21.0 | 27.9 | 20.6 ? |

Types.—Lectotype: 66169d; figured paratypes: 66169b,c; unfigured paratype: 66169a,e.

Horizon and locality.—Trenton group (Sherman Fall formation) in Vermont: Shipyard Bay, Highgate Springs, St. Albans (15') Quadrangle.

Discussion.—This species is distinguished by the strong fold continuous from beak to anterior margin and the consequent deep and wide sulcus in the brachial valve. It differs from *R. americana* in the greater strength of the fold and sulcus.

In defining this species Bassler used 7 specimens, 2 of which came from Pennsylvania and 5 from Vermont. The lot from Pennsylvania consists of 3 pieces representing 2 specimens. Figures 17 and 19 of plate 49 in the Maryland volume represent counterparts of the same specimen. It is here recommended that the Pennsylvania specimens be excluded from the species because they have characters different from those of the Vermont specimens and are here called *R. americana*. Inasmuch as Bassler intended to honor George E. Edson of St. Albans, Vt., one of the Vermont specimens should be selected as type specimen. Specimen 66169d is selected from Bassler's cotype lot from Highgate Springs, Vt. Although this specimen was not figured by Bassler, it is the most complete of the lot and shows best the specific characters emphasized herein.

REUSCHELLA VESPERTINA Cooper, new species

Plate 186, C, figures 11, 12; plate 269, B, figures 6-10

Shell of medium size for the genus, wider than long, rectangular in outline; hinge slightly narrower than the midwidth; sides slightly oblique; anterolateral extremities narrowly rounded; anterior margin broadly rounded; anterior commissure strongly sulcate; costellae numbering 10 to 12 in 5 mm. at the anterior margin of a large specimen.

Pedicle valve gently concave in lateral profile, flat or gently concave in anterior profile; umbo narrowly convex to carinate and extended anteriorly to the front margin as a strong, narrow fold. Flanks bounding fold flat to concave; sides deflected strongly in the direction of the pedicle valve. Interarea apsacline, moderately long.

Brachial valve gently convex in lateral profile and broadly convex in anterior profile but with the sides steep. Umbo and medial region deeply sulcate, the sulcus extending to the anterior margin. Flanks bounding sulcus narrowly rounded, slopes of flanks steep; posterolateral extremities deflected toward the brachial valve.

Interior unknown.

Measurements in mm.—Holotype, length 21.2, length of brachial valve 21.7, midwidth 27.2, hinge width 27.0, thickness 6.4.

Types.—Holotype: 124230a; figured paratypes: 123255b,c; 124230b; unfigured paratype: 123255a.

Horizon and locality.—Upper part of the dark shale under the Eureka quartzite in Nevada: Under two knobs of Eureka quartzite, north side of canyon, 3.1 miles N. 32° E. of the Blair (Segura) Ranch, Antelope Mountains; on the north-facing nose of hill 8167, Martins Ridge, Monitor Range, Roberts Mountains (1°) Quadrangle.

Discussion.—This species is characterized by the prominence of its fold and sulcus and the strongly deflected sides and posterolateral extremities. It differs from *R. americana* in not attaining the great size of that species, in having a broader fold and sulcus and more subdued costellae. This species is common in the upper part of the dark shales below the Eureka quartzite, but well-preserved specimens are rare.

Family LINOPORELLIDAE Schuchert and Cooper, 1931

Dalmanellacea having a cruralium in the brachial vave.

LATICRURA Cooper, new genus(Latin *latus*, wide; *crus*, leg)

Shells pionodemoid in outline and profile; with a long interarea, and open delthyrium. Anterior commissure sulcate. Surface multicostellate, with scattered, swollen, and hollow costellae as in *Pionodema*. Shell punctate.

Inside the pedicle valve the dental plates are well developed, slender, receding. The anterior ends of the dental plates are continued along the floor of the valve

as low ridges bounding the muscle area. Pedicle attached to a small apical plate fixed on the sides of the dental plates at the apex. Muscle area elongate, with elongate and narrow diductor scars. Adductor track narrow, not elevated.

Brachial valve with a deep notothyrial cavity formed by the convergence of the brachiophore plates to unite with the median septum. Brachiophores long and broad, grooved on the outside and forming an inverted S in section. Median ridge strong and high. Cardinal process a low and simple ridge on the floor of the notothyrial cavity.

Genotype.—*Laticrura pionodema* Cooper, new species.

Discussion.—This genus is best characterized by a combination of exterior and interior features. The known species all have an elongate beak and a long interarea with long, narrow delthyrium. The surface is marked by costellae, usually not brought into fasciculae. Isolated swollen and hollow costellae as in *Pionodema* are often present, and one species was individualized on the strength of their development.

Inside the pedicle valve the strong, receding dental plates are distinctive. The anterior ends of the plates are usually continued anteriorly to the front end of the muscle scars. The teeth are small but have deep fossettes. In some specimens, particularly of *L. latibrachiata*, a small plate appears in the apex of the delthyrium. This plate is short and is located on the sides of the dental plates between the floor of the delthyrial cavity and the surface of the delthyrium.

The most distinctive feature of the brachial valve is the large brachiophore with its great length and width. This is anchored to the median ridge by converging brachiophore supporting plates. These form a narrow notothyrial cavity not unlike that of *Scaphorthis* and *Corineorthis* among the impunctate genera and *Linoporella* of the punctate genera. The cardinal process is a thin, simple blade on the floor of the notothyrial cavity. No other punctate genus is similar to this one in interior details, the brachiophores being unique. *Linoporella* is similar in the form of the notothyrial cavity but is externally different and is not provided with the enormous brachiophores.

LATICRURA HETEROPLEURA Cooper, new species

Plate 143, F, figures 25-29; plate 221, A, figures 1-6

Large for the genus, wider than long, subrectangular in outline; hinge not quite equal to widest part which is at about the middle; sides gently rounded; anterolateral extremities narrowly rounded; anterior margin broadly rounded; anterior commissure sulcate; surface costellate, costellae numbering about 4 or 5 to the millimeter at the front margin; surface marked also by numerous swollen and enlarged costellae.

Pedicle valve with elongate and erect beak; umbo swollen, narrow; lateral profile gently convex; anterior profile narrowly convex in the median region but with long and moderately steep lateral slopes; middle narrowly convex and forming a poorly defined fold. Flanks slightly convex.

Brachial valve unevenly convex in lateral profile, the posterior half gently con-

vex, the anterior half moderately bent toward the pedicle valve; beak well defined, protruding posterior to the posterior margin; umbo swollen, sulcate; sulcus deep and narrow; forming a short tongue at its anterior end. Flanks swollen with moderate slopes to the lateral margins and medianly to the sulcus.

Measurements in mm.—Holotype, length 8.9, brachial length 7.6, width 10.2, hinge width 8.8, thickness 5.9.

Types.—Holotype: 117263a; figured paratype: 117263d; unfigured paratypes: 117263b,c,e.

Horizon and locality.—Little Oak formation in Alabama: At the junction of the Bailey Gap and Cahaba Valley roads, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 13, T. 19 S., R. 2 W., 1 $\frac{3}{4}$ miles northeast of Newhope Church, Vandiver (15') Quadrangle; cut on U. S. Highway 31, $\frac{1}{2}$ mile north of Pelham, Bessemer Iron District (15') Quadrangle.

Discussion.—This species is distinguished from the others described herein by the great development of swollen and hollow costellae on the exterior. It has a deeper and more pronounced sulcus in the brachial valve than that of *L. pionodema*. It is closest to *L. latibrachiata* but differs in ornamentation and in a more erect and incurved beak.

LATICRURA LATIBRACHIATA Cooper, new species

Plate 143, E, figures 19-24; plate 145, A, figures 1-13; plate 149, B, figures 4-9

Shell subcircular in outline, with the length and width about equal. Hinge narrower than the greatest width which is near the middle. Lateral margins rounded; front margin broadly rounded to slightly emarginate at the middle. Anterior commissure sulcate. Surface multicostellate, with about 4 costellae in the space of 1 mm. at the front margin.

Pedicle valve gently convex in lateral profile; somewhat carinate in anterior profile. Middle of valve from the beak to the anterior margin swollen a little to form a low and poorly defined fold which is also responsible for the slight emargination of the front. Lateral slopes from the fold to the margins steep. Interarea elongate, curved; beak strongly incurved, narrow and sharp.

Brachial valve nearly equal to the pedicle valve in depth, moderately convex in lateral profile, lobate in anterior profile. Sulcus, shallow and narrow, originating at the umbo and extending to the front margin where the valve is extended slightly to form a short but inconspicuous tongue. Flanks swollen with fairly steep slopes to the sulcus and the lateral margins. Lateral slopes steepest toward the cardinal extremities; slopes to the sulcus short and steep. Interarea long for this structure on a brachial valve.

Interior of the pedicle valve characterized by good development of the apical plate, and the brachial valve by the ponderous development of the brachiophores.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.9 | 8.1 | 9.6 | 8.0 | 6.6 |
| Paratype (117265p)..... | 8.0 | 7.5 | 9.5 | 7.3 | 5.0 |

Types.—Holotype: 118041a; figured paratypes: 117264a-c, 117265a,b,d,f, h,k,p; unfigured paratypes: 117265c,e,g,i,j,l-o,q, 117266a-h.

Horizon and locality.—Arline formation (lower-middle) in Concord (T.V.A. 138-SW) Quadrangle, Tennessee: In glade $\frac{1}{4}$ mile southeast of Friendsville; 100 yards southwest of the Negro Cemetery, $\frac{1}{2}$ mile northeast of Friendsville.

Discussion.—Fine silicified specimens of this species occur at Friendsville. Although the silicification is coarser than that of some of the other genera at this place, it is sufficiently good to yield excellent study material. The important specific characters are the ornamentation, well-developed sulcus which originates at the umbo, the well-developed apical plate, and the ponderous cardinalia. The ornamentation is stronger than that of *L. pionodema*, the apical plate is better developed, and the cardinalia more robust.

LATICRURA MAGNA Cooper, new species

Plate 144, B, figures 26-29; plate 145, C, figures 20-23

Shell large, subcircular in outline, with the greatest width at the middle; hinge narrower than the greatest width; sides and anterior margin broadly rounded; costellae fine and crowded, appearing in several generations, about 4 to the millimeter at the anterior margin of the holotype.

Pedicle valve most convex in the umbonal region when seen in lateral view; anterior portion somewhat flattened. Anterior profile with median region narrowly rounded and with long, fairly gentle slopes to the margins. Interarea strongly apsacline, beak short and slightly incurved.

Brachial valve most convex at the umbo in lateral profile; broadly convex in anterior profile. Beak prominent; umbo swollen; sulcus originating at the beak, narrow and shallow and extending to the anterior margin. Flanks gently swollen.

Measurements in mm.—Holotype, length 10.5, brachial length 10.0, width 13.7, hinge width 11.0, thickness ?.

Types.—Holotype: 117267a; figured paratypes: 117267b, 117268a; unfigured paratypes: 117267c, 117268b,c.

Horizon and locality.—Oranda formation in Virginia: 0.6 mile northwest of Linville, Broadway (15') Quadrangle. On the railroad $\frac{1}{2}$ mile west of Strasburg; Lee Highway (U. S. 11), $1\frac{1}{2}$ miles southwest of Strasburg; Strasburg (15') Quadrangle.

Same formation in Pennsylvania: 1 mile north of Guilford Springs, Chambersburg (15') Quadrangle.

Martinsburg formation (part with *Brongniartella*=Salona) in Virginia: On Virginia Highway 617=910, 0.15 mile north of Green Mount Church, Broadway (15') Quadrangle.

Discussion.—This species is distinguished from the others herein described by its much greater size, and its strongly apsacline, almost procline interarea, slightly incurved beak, and sides sloping rapidly toward the middle. The species is a rare shell at all localities where it has been seen.

LATICRURA PIONODEMA Cooper, new species

Plate 144, A, figures 1-25; plate 144, C, figures 30-33; plate 145, B, figures 14-19;
plate 146, A, figures 1-4

Shell of about the same size as *L. latibrachiata*, about as wide as long; cardinal extremities well rounded; lateral margins very slightly curved; anterior margin narrowly rounded. Anterior commissure moderately sulcate. Surface finely multicostellate, with 5 costellae in 1 mm. at the front margin of the holotype.

Pedicle valve moderately convex in lateral profile, with the umbo forming the most convex part. Anterior margin narrowly rounded. Fold low and inconspicuous; slopes to the lateral margins steep. Interarea long, strongly curved; beak sharp and strongly incurved. Delthyrium narrow.

Brachial valve moderately convex in lateral profile, slightly shallower than the pedicle valve. Anterior third subgeniculate and protruding slightly to form a short tongue. Sulcus broad and shallow, originating at the umbo. Flanks slightly swollen. Slopes to cardinal extremities fairly steep; lateral slopes moderately inclined. Interarea moderately long, beak incurved.

Measurements in mm.—Holotype, length 11.4, dorsal length 10.3, width 11.0, hinge width 8.0, thickness 6.0.

Types.—Holotype: 117272i; figured paratypes: 117269e,g,i,k,l, 117270a,b,d, 117271b,g, 117272e,g, 117273, 117274a,b; unfigured paratypes: 117269a-d,f,h, j,m,n, 117270c,e-g, 117271a,c-f, 117272a-d,f,h, 117274c,d.

Horizon and locality.—Effna-Rich Valley formations in Virginia: At Porterfield Quarry, 5 miles east of Saltville, Maccrady (T.V.A. 218-NW) Quadrangle.

Edinburg formation (base of Liberty Hall facies) in Virginia: 1.8 miles S. 4° W. of Bethel Church, 5.9 miles east of Harrisonburg, Harrisonburg (15') Quadrangle.

Edinburg formation (*Cyrtonotella* zone) in Virginia: Just above quarry $\frac{1}{8}$ mile northeast of Strasburg Junction, Strasburg (15') Quadrangle.

Pratt Ferry formation in Alabama: 0.2 miles southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—This species is characterized by its rotund form, its fine, even costellae, lack of an apical plate, and broad, shallow sulcus on the brachial valve. It is most like *L. latibrachiata* but differs in having a broader and shallower sulcus and in lacking a deltidial plate. It also possesses a more erect beak than the Friendsville species.

ELASMOTHYRIS Cooper, new genus

(Greek *elasma*, plate; *thyris*, opening)

Shell small, biconvex with deep valves, the pedicle valve being the deeper; outline subrectangular; sides and anterior rounded; hinge wide but less than the midwidth; anterior commissure sulcate. Pedicle interarea long, delthyrium open; surface multicostellate. Shell interarea long, delthyrium open; surface multicostellate. Shell substance punctate.

Pedicle interior with long, slender teeth and deep delthyrial cavity; dental plates receding, flaring laterally and attached to the sides; muscles attached to a thin horizontal plate laid across the delthyrial cavity at the base of the dental plates and attached to the sides of the valve to leave a deep delthyrial chamber between the plate and the valve floor. Muscle scars well impressed on plate; adjustor-diductor scars located at base of dental plates; adductor (?) scars broad, occupying median region and separated from other scars by low ridges.

Brachial valve with small, deep sockets defined by a fulcral plate; notothyrial cavity formed by brachiophore plates uniting with a median septum and the valve floor; brachiophores long and slender; cardinal process located at the end of a low septum occupying the floor of the notothyrial chamber and with a bulbous myophore; median septum thin, elevated anteriorly but not reaching the front margin.

Genotype.—*Elasmothyris concinnula* Cooper, new species.

Discussion.—This interesting little shell is characterized externally by considerable depth in both valves, costellate ornamentation, and a general resemblance to *Skenidioides*. The interior, however, is marked by normal dental plates and a horizontal muscle plate in the pedicle valve, and a notothyrial chamber and long, slender brachiophores in the brachial valve. Besides these features the shell substance is punctate.

Several characters of this peculiar genus need explanation. The determination of the presence of punctae rests on observation of silicified shells. This is not ordinarily a type of preservation that yields good evidence of these important structures, but in this instance nearly every specimen shows small black spots on both sides of the shell, some of which are radially arranged. These are taken to be fillings of punctae by mud, pyrite, or other impurity. Confirmation of the punctate condition is to be seen also in the structures of the brachial valve which are discussed below. The absence of a deltidium in such an early brachiopod is negative evidence.

The pedicle valve is characterized by strong, sharp teeth buttressed by receding dental plates which flare laterally and are attached to the sides of the valve. The plates are normal in every respect, but at their base a plate is built horizontally across the delthyrial chamber. This plate divides the delthyrial cavity into an upper and lower chamber. The plate is also marked by 2 oblique ridges that clearly indicate the position of muscle scars.

At the base of the dental plates is an elongate, tear-shaped scar than can be interpreted in two ways: it is the adjustor scar which is usually found in that situation, or it is a scar of the diductor and adjustor muscles with no evidence left on the shell by which the individual scars may be differentiated. On this interpretation the adductor field is fairly large but no individual scars can be differentiated. The horizontal plate is somewhat variable in form. In some specimens it is horizontal and nearly flat. In others it is bowed medially in the direction of the brachial valve. This plate sets *Elasmothyris* quite apart from any of the other skenidioid shells such as *Skenidioides*, *Tropidothyris*, or *Skenidium*.

The brachial valve of *Elasmothyris* suggests that of the punctate shell *Lino-*

porella in the form of its cardinal process and notothyrial chamber. It is frequent in punctate shells for the median septum to be continued posteriorly along the floor of the notothyrial chamber and unite with the shaft of the cardinal process. Such is the case in *Elasmothyris*, and the brachial structures are in support of the idea that the shell is punctate. Specimens of *Elasmothyris* are very small and not always well preserved, but the cardinal process appears to have a bulbous or expanded myophore such as that of *Linoporella* or other dalmanelloid brachiopods. The latter feature and the posterior continuation of the median septum differentiate *Elasmothyris* from the other skenidioid genera mentioned above.

ELASMOTHYRIS CONCINNULA Cooper, new species

Plate 99, F, figures 35-42

Shell minute, wider than long and with the hinge less than the midwidth; sides gently rounded; anterior margin broadly rounded to truncated; anterior commissure strongly sulcate. Surface costellate, costellae increasing by intercalation; anteriorly somewhat fascicostellate.

Pedicle valve moderately convex in lateral profile, with the maximum convexity in the posterior third; anterior profile domed and narrowed medianly. Umbonal and median region swollen to form a low fold extending from beak to anterior margin. Flanks on each side of fold descending steeply to the margins. Interarea long; beak slightly incurved. Interior as described for the genus.

Brachial valve unevenly convex with the posterior somewhat flattened and the anterior curved moderately toward the pedicle valve; umbo gently convex; sulcus originating just anterior to the umbo, widening and deepening anteriorly to the margin where a short tongue is formed. Flanks bounding sulcus moderately swollen; posterolateral extremities deflected toward the pedicle valve and flattened. Interior as described for the genus.

Measurements in mm.—Holotype, length 1.2, brachial length 1.3, midwidth 1.5, hinge width 1.3, thickness 1.0.

Types.—Holotype: 117371a; figured paratypes: 117371b-d.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—No other species of this genus is known to which this one may be compared.

Family SCHIZOPHORIIDAE Schuchert, 1929

Dalmanellacea having lenticular or resupinate profile and fine costellae; brachial interior characterized by erect, subparallel to divergent brachiophore supporting plates and slender, solid brachiophores; sockets defined by fulcral plates.

Subfamily SCHIZOPHORIINAE Schuchert, 1929

Finely costellate, unplicated Schizophoriidae.

Genus *PIONODEMA* Foerste, 1912

Pionodema FOERSTE, Bull. Sci. Lab., Denison Univ., vol. 17, p. 139, 1912.—COOPER, Journ. Paleont., vol. 4, pp. 369-382, 1930.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, pp. 141-142, 1932.

PIONODEMA CAMERATA Cooper, new species

Plate 162, E, figures 24-32

Shell of moderate size for the genus, wider than long, subrectangular in outline; widest at about the middle; hinge narrow; sides rounded; anterior gently rounded; surface marked by costellae that number 14 or 15 in 5 mm. at the front of an adult shell.

Pedicle valve moderately convex in lateral profile, with the maximum curvature just anterior to the umbo and the anterior half somewhat flattened; anterior profile broadly and fairly strongly convex; median and umbonal regions swollen; flanks moderately convex but with moderate slopes to the margin. Interior with large bilobed muscle area with somewhat elongate diductors and a long median ridge extending anteriorly from the adductor field; region on each side of muscle area marked by oblique, elongate ridges.

Brachial valve with lateral profile slightly more convex than that of the pedicle valve and with the maximum convexity in the umbonal region. Anterior profile somewhat strongly domed. Umbonal and median regions strongly swollen; anterior slope long and moderately steep. Flanks convex, and with short and steep slopes. Interior with brachiophore plates swinging anteriorly to meet and form a long V-shaped chamber. Cardinal process with long shaft and small lobate myophore.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-----------------------|--------|-----------------|----------|-------------|-----------|
| Holotype | ? | 11.4 | 14.2 | 8.0 ? | 3.6 ? |
| Paratype (117343a)... | 11.4 | ? | 14.5 | 10.2 | 2.7 ? |
| " (117343q)... | ? | 10.7 | 11.3 | 8.8 | 2.0 ? |

Types.—Holotype: 117343k; figured paratypes: 117343a-c,i,j,m,o; unfigured paratypes: d-h,l,n,p,q.

Horizon and locality.—Sevier formation (Bacon Bend member-top, just under Bays red beds) in Tennessee: $\frac{1}{4}$ mile northeast of Fourmile Church, Tallassee (T.V.A. 139-SE) Quadrangle.

Discussion.—This species is characterized by moderately strong ornamentation but more especially by the camerate arrangement of the brachiophore plates of the brachial valve. None of the specimens, which are all preserved as impressions of the interior or exterior, shows unequivocal traces of punctae. This made it difficult to decide whether the species belongs to *Pionodema* or *Doleroides*, because the brachial plates suggest the latter genus. It was decided that *Pionodema* is the correct genus because of the character of the pedicle muscle area and the nature of the cardinal process.

The pedicle muscle area is like that of *Pionodema* rather than *Doleroides* be-

cause of the presence of the low median septum extending anterior to the adductor impression. The cardinal process has a thin but long shaft and is surmounted by a small lobate myophore like that of *Pionodema*. The brachial plates are flaring and like *Pionodema*, but they are extended anteriorly and inward to surround the anterior end of the cardinal process shaft and thus to form a long, partially enclosed chamber that simulates *Doleroides*. No other species of *Pionodema* has been seen with such a structure, although some specimens of *P. subaequata* approach it. This species is important because it occurs just under the Bays red beds and thus helps to date the red bed series and the Sevier under it. This *Pionodema* suggests an early Trenton age for the beds in which it occurs.

PIONODEMA CIRCULARIS (N. H. Winchell)

Plate 154, A, figures 1-5; plate 154, B, figures 6-11

Orthis circularis N. H. WINCHELL, 8th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 66, 1880.

Orthis (Dalmanella) subaequata circularis (N. H. Winchell) WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 452, pl. 33, figs. 46, 47, 1895.

Pionodema subaequata circularis (N. H. Winchell) BASSLER, U. S. Nat. Mus. Bull. 92, vol. 2, p. 978, 1915.

Pionodema cf. *subaequata* (not Conrad) COOPER, Journ. Paleont., vol. 4, No. 4, pl. 36, fig. 5, 1930.

Shell large for the genus, subcircular in outline; hinge narrow, slightly less than two-thirds the width. Cardinal extremities obtuse; sides and anterior margin broadly rounded. Anterior commissure gently uniplicate. Very finely costellate, costellae crowded along the front margin and numbering 3 to 4 per millimeter in the fold and sulcus region but 4 to 5 per millimeter on the flanks. Hollow costellae not strongly swollen, concentrated on fold and in sulcus but also scattered over most of the surface.

Pedicle valve unevenly convex in lateral profile and with the maximum curvature near the middle; anterior third somewhat flattened; anterior profile broadly and moderately convex, most so in the middle and with moderately steep, flat sides. Beak small and strongly incurved; umbo swollen; median region swollen; anterior third depressed to form a broad and shallow sulcus; flanks somewhat flattened. Interarea curved, apsacline.

Pedicle interior with prominent oval muscle field; diductor scars elongate, somewhat flabellate anteriorly; adductor scars located on the sides of a prominent median ridge.

Brachial valve moderately convex in lateral profile and with a strongly convex umbo; anterior profile moderately and fairly evenly convex and with slightly less depth than the pedicle valve. Umbo gently and narrowly sulcate, the sulcus disappearing about one-third the length from the beak; median region swollen; lateral slopes moderately steep. Beak small, incurved. Median fold generally indistinct. Brachial interior with small cardinal process having a short shaft; brachioophore plates short and flaring. Median ridge low and inconspicuous.

Measurements in mm.—

| | | Length | Brachial length | Width | Hinge width | Thickness |
|----------|----------------|--------|--------------------|-------|----------------|-----------|
| Hypotype | (117323)..... | 20.8 | 19.6 | 23.1 | 13.0 | 12.0 |
| " | (117324a)..... | 18.7 | 17.4 | 19.5 | 12.5 | 11.0 |
| " | (117324b)..... | 16.8 | 15.4 | 18.0 | 11.7 | 9.1 |
| " | (48683)..... | 9.9 | 9.1 | 10.7 | 7.5 | 6.3 |

Types.—Figured hypotypes: 48683, 117323, measured hypotypes: 117324a,b.

Horizon and locality.—Decorah formation (Ion member—*Phylloporina* and Fucoid beds) in Minnesota: At St. Paul; Kenyon, Goodhue County; Fort Snelling, Hennepin County; Milton, Dodge County; cut 1 mile east, 1 mile north, and $\frac{1}{4}$ mile east of Wanamingo, Goodhue County; Wagner Hill, 5 miles south of Cannon Falls, Goodhue County; cut on the county road 1.1 miles east of U. S. Highway 52 on the south edge of Cannon Falls, Goodhue County; Elmira, Olmstead County.

Decorah formation (Ion member) on the Platteville road in Wisconsin: 3.5 miles southeast of Lancaster, Lancaster (30') Quadrangle; Wisconsin Highway 10, $\frac{1}{4}$ mile west of Ellsworth, Pierre County.

Decorah formation (Ion member—*Phylloporina* bed) in Iowa: At Decorah, Winneshiek County.

Discussion.—This species is characterized by its nearly circular form (L/W usually 0.90 or greater), narrow hinge, strongly rounded contours, and generally fine costellae. In size this species is like *P. minnesotensis* and *P. subaequata* but differs markedly from both of them. The wide hinge and shouldered outline of *P. minnesotensis* are features which separate that species readily from *P. circularis*.

Some specimens of *P. subaequata* have an outline like that of *P. circularis* and have almost the same length/width index, but the former species is much more strongly costellated than *P. circularis*. Furthermore, *P. subaequata* generally has a strong concentration of swollen costellae in the median region.

PIONODEMA CONRADI (N. H. Winchell)

Plate 154, C, figures 12-14; plate 162, A, figures 1-6

Orthis conradi N. H. WINCHELL, 8th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 68, 1880.

Orthis subaequata HALL (not Conrad), Pal. New York, vol. 1, p. 118, pl. 32, figs. 2e, f (not 2a-d), 1843.

Orthis (Dalmanella) subaequata conradi (N. H. Winchell) WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 449, pl. 33, figs. 37-39, 1895.

Pionodema subaequata conradi (N. H. Winchell) BASSLER, U. S. Nat. Mus. Bull. 92, p. 978, 1915.

Shell small for the genus, subcircular in outline; hinge narrow, equal to about two-thirds the width; sides and anterior margin rounded; anterior commissure varying from rectimarginate to slightly uniplicate. Costellae of unequal size, crowded, numbering 2 to 5 to the millimeter at the front margin; numerous costellae swollen and usually separated from each other by a very fine intercalated costella at the front margin.

Pedicle valve unevenly convex in lateral profile, the convexity located just anterior to the umbo and the anterior third to half flattened. Anterior profile broadly and moderately convex. Beak small, gently incurved; umbonal region swollen; median region inflated; lateral slopes steep but anterior slope long and gentle. Interarea moderately curved, strongly apsacline. Dental plates long; muscle field large and oval.

Brachial valve less deep than the pedicle valve, moderately convex in lateral profile; anterior profile broadly and moderately convex. Umbo marked by short and shallow sulcus; median region swollen; lateral slopes short and moderately steep. Brachioophore plates long.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (117325a)... | 10.8 | 9.7 | 11.3 | 7.6 | 6.0 |
| " (15749a).... | 9.1 | 8.1 | 9.3 | 6.6 | 5.1 |

Types.—Figured hypotypes: 15749a, 117325a.

Horizon and locality.—Platteville formation (McGregor member) in Wisconsin: At Beloit, Rock County; 0.1 mile south of the Little Platte River on Wisconsin Highway 81, 2 miles northwest of Platteville, Mineral Point (30') Quadrangle; Janesville, Rock County; quarry on Wisconsin Highway 81, 1 mile northwest of Ellenboro, Lancaster (30') Quadrangle.

Same horizon in Minnesota: At Fort Snelling, Hennepin County; on U. S. Highway 52, 2 to 3 miles north of Fountain, Goodhue County; Minneapolis.

Same horizon in Illinois: At Dixon, Dixon (15') Quadrangle.

Discussion.—This is a small subcircular species with moderately strong costellae. At the median anterior margin of the brachial valve the costellae are often alternately large and small and much crowded. This feature makes it possible to identify poorly preserved or fragmentary specimens if this portion of the shell is preserved. Its small size makes this species comparable to *P. minuscula* and *P. sulcata*.

Pionodema conradi differs from *P. minuscula* in being more circular in outline, having a narrower hinge, and in being more strongly costellate. It differs from *P. sulcata* in being generally smaller and in lacking the prominent but narrow sulcus on the pedicle valve of the Appalachian species. Moreover the costellation of the two species is quite unlike because *P. sulcata* has fairly even costellae without the anterior alternation.

PIONODEMA CRASSIPUNCTATA Cooper, new species

Plate 82, F, figures 23-27

Shell small for the genus, wider than long, transversely subrectangular in outline with the hinge slightly less than the midwidth which is the greatest width; sides nearly parallel; cardinal extremities approximately a right angle; anterior margin broadly rounded; anterior commissure gently sulcate. Surface multicostellate, 4 costellae in 1 mm. at the front margin. Shell substance coarsely punctate.

Pedicle valve unevenly convex in lateral profile and with the maximum convexity posterior to the middle; anterior profile broadly subcarinate, with long, steep sides and narrowly rounded median region; umbo narrowly convex, the convexity continued to the anterior margin as a narrowly rounded fold; flanks slightly concave. Interarea moderately long, apsacline.

Brachial valve with gently convex lateral profile having the maximum curvature in the posterior part; anterior profile gently and broadly convex; sulcus shallow, originating at the umbo and expanding anteriorly to the front margin where it occupies about half the shell width. Flanks bounding sulcus gently swollen; posterolateral extremities flattened and deflected slightly toward the pedicle valve. Brachiophore plates widely divergent.

Measurements in mm.—Holotype, length 6.7, brachial length 6.2, midwidth 9.1, hinge width 8.9, thickness 3.4.

Type.—Holotype: 117326.

Horizon and locality.—Benbolt formation (base) in Virginia: 0.2 mile south of the middle fork of Moccasin Creek, $1\frac{1}{2}$ miles south of Hansonville, Hansonville (T.V.A. 205-SW) Quadrangle.

Discussion.—This species is characterized by its transverse form, rectangular outline, fine costellae, and the coarse punctae mostly radially arranged. This species is more transverse than any of the other known species.

PIONODEMA MINNESOTENSIS Cooper

Plate 154, D, figures 15-19

Orthis (Dalmanella) subaequata WINCHELL and SCHUCHERT (not Conrad), Geol. Minnesota, vol. 3, pl. 33, figs. 33, 34, 1895.

Pionodema minnesotensis COOPER, Journ. Paleont., vol. 4, No. 4, p. 379, pl. 36, fig. 14, 1930.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, pl. 23, figs. 6, 10, 14, 1932.

This name was proposed for specimens having a wide hinge and distinctly formed shoulders. It is ornamented like *P. subaequata*. It is also a robust species attaining nearly as large a size as the largest known specimens of that species.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 17.2 | 15.3 | 20.0 | 16.0 | 10.0 |
| Hypotype (117327a)... | 17.0 | 16.1 | 19.2 | 15.2 | 11.3 |
| " (117327b)... | 19.3 | 17.9 | 21.5 | 16.4 | 12.6 |

Types.—Holotype: Y.P.M. S-1356; figured hypotype: 117327a; measured hypotype: 117327b.

Horizon and locality.—Decorah formation (Ion member ?) in Minnesota: At Chatfield, Fillmore County; Minneapolis; St. Paul; and Fountain, Fillmore County.

PIONODEMA MINUSCULA Willard

Plate 155, A, figures 1-10; plate 155, G, figures 32-42

Pionodema minuscula WILLARD, Bull. Mus. Comp. Zool., Harvard Coll., vol. 68, No. 6, p. 275, pl. 2, fig. 3, 1928.

Small for the genus, slightly wider than long; hinge narrow; cardinal extremities obtuse; sides and anterior margin gently rounded; anterior commissure broadly uniplicate in adults. Costellae fine, crowded, unequal in size, those on the fold and sulcus stronger than those on the flanks. Costellae in fold and sulcus 2 or 3 in 1 mm.; on the flanks costellae number 4, rarely 5, to the millimeter at the front margin.

Pedicle valve with uneven lateral profile, the posterior part convex but the anterior quarter somewhat flattened; anterior profile gently and broadly convex; beak slightly curved, somewhat erect; umbo somewhat narrowly swollen; median region convex; lateral slopes short and fairly steep. Anterior quarter depressed gently to form a shallow sulcus. Interarea gently curved, apsacline.

Brachial valve about equal to the pedicle valve in depth, fairly evenly and moderately convex in lateral profile. Anterior profile broadly and moderately convex. Umbo with a small sulcus; umbo and median region longitudinally swollen to form a poorly defined fold. Lateral slopes moderately long and gentle. Interior with small cardinal process and widely spaced, subparallel brachiophore supporting plates.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.3 | 11.8 | 13.7 | 8.8 | 7.0 |
| Hypotype (117329a) .. | 11.6 | 10.8 | 12.7 | 8.7 | 6.9 |
| " (117329b) .. | 9.3 | 8.6 | 10.5 | 8.0 | 5.9 |

Types.—Holotype: M.C.Z. 8610; figured hypotypes: Columbia Univ. 26405 (1013) a-c; U.S.N.M. 117328, 117329a; measured hypotype: 117329b.

Horizon and locality.—Lebanon formation in Tennessee: At Lebanon, Wilson County; La Vergne, Rutherford County; Columbia, Maury County; Shelbyville, Bedford County; U. S. Highway 241, 1½ miles southwest of Christiana, Rutherford County; U. S. Highway 41 at Mount Olivet, 10 miles southeast of Murfreesboro, Rutherford County; Wells Creek, Stewart County.

Camp Nelson formation in Kentucky: At High Bridge and 3 miles south of High Bridge, Harrodsburg (30') Quadrangle.

Witten formation in Virginia and Tennessee: At many localities but specimens usually poor.

Hatter formation (Hostler member) in Pennsylvania: At Waterside, Everett (15') Quadrangle.

Discussion.—This species is distinguished by its generally small size, subquadrate outline, and fine costellae. It is thus like *P. conradi* but differs in its squarer form, in its fine costellae, and generally wider hinge. It differs from *P. sulcata* in its subquadrate rather than subcircular outline, finer costellae, and lack of the conspicuous sulcus on the brachial valve.

PIONODEMA SINUATA Okulitch

Pionodema sinuata OKULITCH, Canadian Field-Nat., vol. 49, No. 6, p. 97, pl. 1, fig. 8, 1935.

Type.—Peter Redpath Mus., McGill Univ., Montreal.

Horizon and locality.—Leray limestone = Chaumont in Quebec, Canada: At St. Vincent de Paul and Pointe Claire.

PIONODEMA SUBAEQUATA (Conrad)

Plate 154, E, figures 20-24; plate 155, C, figures 14-18; plate 156, A, figures 1-13;
plate 157, D, figures 7-14

Orthis subaequata CONRAD, Proc. Acad. Nat. Sci. Philadelphia, vol. 1, p. 333, 1843.—HALL, Pal. New York, vol. 1, p. 118, pl. 32, figs. 2a-d (not e-f), 1847; Geol. Wisconsin, vol. 1, p. 42, figs. 1-3, 1862.—EMMONS, Amer. Geology, vol. 1, pt. 2, p. 194, pl. 9, fig. 2, 1855.—LESLEY, Geol. Surv. Pennsylvania, Rep. P4, p. 533, 1889.

Dalmanella subaequata (Conrad) HALL and CLARKE, Pal. New York, vol. 8, pt. 1, pp. 194, 207, 224, pl. 5C, figs. 6-11, 1892.—? WELLER, Geol. Surv. New Jersey, Paleont., vol. 3, p. 156, pl. 10, figs. 3, 4, 1903.

Dalmanella perveta HALL and CLARKE (not Conrad), Pal. New York, vol. 8, pt. 1, p. 224, pl. 5C, figs. 13, 14, 1892.

Orthis minneapolis N. H. WINCHELL, 8th Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, p. 63, 1880.—WINCHELL and SCHUCHERT, Geol. Minnesota, vol. 3, p. 448, pl. 33, figs. 30-32, 1895.

Pionodema subaequata (Conrad) SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 141, pl. 23, figs. 1, 5, 1932.—COOPER, Journ. Paleont., vol. 4, No. 4, p. 378, pl. 36, figs. 1, 3, 1930.

Shell variable in outline and profile, large for the genus, subrectangular to subcircular in outline; valves subequal in depth; hinge usually narrower than the greatest width which is at the middle; cardinal extremities varying from strongly obtuse to nearly a right angle; sides varying from moderately curved to nearly straight; anterior margin broadly convex; anterior commissure varying from nearly rectimarginate to broadly but gently uniplicate. Surface costellate, costellae generally crowded, unequal in size, the coarser ones concentrated in the median region of both valves; strongly swollen and hollow costellae numerous, scattered over the surface and concentrated in the median regions of both valves.

Pedicle valve unevenly convex in lateral profile but with the maximum convexity between the beak and the middle; anterior quarter to half of the profile flattened; anterior profile broadly convex with the median region elevated and with long lateral slopes. Beak moderately long, slightly incurved; umbo somewhat narrowly swollen; median region full; flanks flattened to gently convex, moderately steep; anterior slope convex, fairly steep. Anterior portion somewhat flattened to produce a poorly defined sulcus.

Brachial valve with fairly evenly convex lateral profile having the deepest part at or near the middle; anterior profile broadly convex; umbo sulcate; sulcus shallow, disappearing near the middle; median region swollen, the swelling including the anterior portion which forms an ill-defined fold. Lateral slopes moderately steep.

Pedicle valve with small teeth, receding dental plates, and subflabellate muscle

field; diductor scars subcrescentic; adductor scars large, located posterior to a longitudinal ridge that extends to about the middle of the valve. Apical plate small but well developed.

Brachial interior with long brachiophores having divergent supporting plates extended as ridges converging on the median ridge, cardinal process small, shaft erect and short; median ridge low, extending anterior to the middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-----------------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 14.5 | 13.2 | 16.0 | 12.0 ? | 8.0 |
| Hypotype (48681a) | 18.0 | 16.7 | 19.6 | 14.3 | 10.0 |
| " (117334a) | 16.5 | 15.1 | 18.1 | 14.8 | 9.3 |
| Topotype and hypotype (123234) .. | 14.5 | ? | 15.8 | 11.7 ? | 4.0 ? |
| Hypotype (85750) | 20.3 | 18.2 | 22.4 | 17.4 | 12.0 |
| " (10127a) | 19.6 | 17.7 | 21.7 | 17.3 | 10.8 |
| " (117333) | 18.6 | 17.5 | 21.6 | 15.7 ? | 13.1 |
| " (117332) | 16.1 | 14.8 | 17.9 | 13.5 | 8.8 |
| " (117335a) | 13.6 | 12.6 | 15.8 | 12.7 | 7.8 |
| " (117335b) | 12.0 | 11.5 | 14.6 | 12.0 | 6.9 |
| " (86574a) | 15.8 | 14.4 | 17.2 | 14.0 | 9.4 |
| " (117330) | 21.5 | 20.2 | 25.0 | 18.5 | 13.6 |

Types.—Holotype (Cooper, 1930): A.M.N.H. 910; figured hypotypes: 48681a, 117232, 117335a,b, 117336a-d, Y.P.M. S1359; measured hypotypes: 10127a, 85750, 86574a, 117330, 117332, 117333, 117334a, 117335a,b, 123234.

Horizon and locality.—Decorah formation (Guttenberg member) in Wisconsin: At Mineral Point, Mineral Point (30') Quadrangle; Platteville, Mineral Point (30') Quadrangle; Dickeyville, Grant County; Etna; 10 miles southwest of Lancaster, Lancaster (30') Quadrangle; Highland, Iowa County.

Same formation in Minnesota: At Minneapolis; West St. Paul; Fillmore, Fillmore County; Spring Grove, Houston County; Fountain, Goodhue County.

Barnhart formation in Missouri: At St. Louis; Koch Valley School on U. S. Highway 61, NE. corner SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T. 41 N., R. 6 E., 2 miles south of Barnhart, Kimmswick (15') Quadrangle; $\frac{3}{4}$ mile north of Riverside; 1 mile southeast of New London, Ralls County.

Decorah formation (Spechts Ferry member) in Minnesota: At Chatfield, Fillmore County; Gunderson Pit, 2 miles northwest of Zumbrota, Goodhue County; St. Paul; Minneapolis; and Guttenberg member?, St. Paul.

Same formation in Wisconsin: In NW $\frac{1}{4}$ sec. 19, T. 3 N., R. 1 W., Platteville Township, Grant County.

Decorah formation in Iowa: At Clermont, Fayette County.

Auburn chert in Missouri: At Apex Station on the C. B. and Q. RR. south of Elsberry; $\frac{1}{2}$ mile east of Auburn, Elsberry (15') Quadrangle.

Discussion.—As here defined this species may be composite because it includes forms which are distinctly rectangular, whereas the type specimen is subcircular in outline. Inasmuch as it is possible to find specimens gradational between the subrectangular form and the subcircular ones, the name is believed to cover the entire range. The rectangular types are located chiefly in Missouri,

but these are associated with rounder specimens. In some localities the subrectangular specimens predominate. It is possible that refinement of the stratigraphy in the Platin group and Decorah formation of Missouri will show the predominantly subrectangular forms to have a different level from that of the rounder ones.

The type specimen of *P. subaequata* is evidently a young specimen, but it is a nearly circular form with numerous swollen costellae concentrated in the median region of both valves. The stratigraphic level of this specimen is evidently the Guttenberg member of the Decorah formation. According to Hall (1847, p. 118) "The species occurs at Mineral Point (Wisconsin), in the Blue limestone associated with *Leptaena sericea*, *Orthis testudinaria*, *Delthyris lynx* and other Trenton limestone fossils." A specimen from the Hall collection (123234) now in the National Museum is a limestone plate containing a pedicle valve of *P. subaequata* having dimensions identical to those of the type specimen. In addition two valves of *Sowerbyella* are present.

Pionodema subaequata is a large species for the genus and may therefore be compared with *P. minnesotensis* and *P. circularis*. It differs from the former in not having the shouldered outline, although the hinge of *P. subaequata* is very wide. *Pionodema subaequata* has a greater proportion of swollen costellae than *P. minnesotensis*. *Pionodema circularis* is readily distinguished from *P. subaequata* by its strongly rounded contours and finer costellae.

PIONODEMA SULCATA Cooper, new species

Plate 155, D, figures 19, 20; plate 155, E, figures 21-30

Shell of about medium size for the genus, slightly wider than long with well-rounded sides and front margin. Anterior commissure nearly rectimarginate. Costellae fine, subequal except on the posterolateral extremities, numbering about 3 to the millimeter at the front margin.

Pedicle valve about as deep or slightly deeper than the brachial valve; lateral profile uneven, most convex just anterior to the umbo and flattened in the anterior half; anterior profile somewhat narrowly swollen in the median region and with long and moderately steep slopes. Beak elevated, slightly incurved; umbo narrowly swollen, the swelling continued anteriorly as a poorly defined narrow fold to about the middle of the valve; lateral slopes long and moderately steep and gently convex. Interarea curved, apsacline.

Brachial valve moderately convex in lateral profile, most convex in the median region. Anterior profile broadly convex and with the median portion slightly flattened and depressed medially by a narrow sulcus. Umbo sulcate, the sulcus shallow and narrow but extending anteriorly at least to the middle of the valve or beyond. Median region inflated; anterior slope moderately steep; lateral slopes short and steep. Cardinal process large, shaft long; brachiphore plates flaring.

Measurements in mm.—Holotype, length 10.7, brachial length 10.0, width 11.6, hinge width 8.1, thickness 6.5.

Types.—Holotype: 117337a; figured paratypes: 117337b, 117338c,d, 117339a,b; unfigured paratypes: 117337c-j, 117338a,b,e.

Horizon and locality.—Cave Creek formation in Virginia: Along the L. and N. RR., 100 yards south of the water tank at Hagan, Rose Hill (T.V.A. 161-NE) Quadrangle; on U. S. Highway 58, $3\frac{1}{4}$ miles east of Cumberland Gap, Wheeler (T.V.A. 153-SE) Quadrangle.

Nealmont formation (upper shaly bed, *Conradella* fauna) in Lewistown (15') Quadrangle, Pennsylvania: At southern (old) quarry of the National Lime Company, Naginey; Reedsville.

Discussion.—This species is suggestive of *P. minuscula* but may be distinguished by its strongly rounded form and the deep but narrow sulcus of the brachial valve. It also suggests *P. sp. 1* from Black River rocks in New York. This unnamed species is like *P. sulcata* in having a prominent sulcus on the brachial valve. The two may ultimately prove to be the same.

PIONODEMA TENNESSEENSIS Cooper, new species

Plate 162, B, figures 7-12

Shell of about medium size for the genus, wider than long, subrectangular in outline; lateral margins gently rounded; anterior margin broadly rounded; hinge wide but narrower than the greatest shell width which is at about the middle. Anterior commissure nearly rectimarginate to gently uniplicate. Costellae moderately strong, fairly even, about 3 to the millimeter at the anterior margin.

Pedicle valve having about the same depth as the brachial one, strongly convex in lateral profile, and strongly convex in anterior profile. Beak large, elevated, incurved; umbo swollen and with steep lateral slopes; median region swollen; anterior slope convex and fairly steep. Median region slightly flattened in the anterior third; lateral slopes short and steep. Interarea long, curved, apsacline.

Brachial valve fairly strongly convex in lateral profile with the maximum depth at about the middle; anterior profile broadly and fairly strongly convex; umbo fairly deeply but narrowly sulcate, the sulcus extending to the middle or slightly anterior to that point; umbo and median region tumid; lateral slopes steep.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 12.2 | 11.3 | 13.4 | 10.7 | 7.7 |
| Paratype (117340b)..... | 13.9 | 12.9 | 15.4 | 10.7 | 10.1 |
| “ (117340c)..... | 11.7 | 11.0 | 13.7 | 9.8 | 6.0 |
| “ (117340d)..... | 8.9 | 8.6 | 11.1 | 9.5 | 5.9 |

Types.—Holotype: 117340a; figured paratype: 117340c; unfigured paratypes: 117340b,d.

Horizon and locality.—Hermitage formation in Tennessee: On the east side of U. S. Highway 70S-41 near its junction with Spence Lane 4.2 to 4.3 miles southeast of Nashville, Hermitage (15') Quadrangle.

Discussion.—This species differs from *P. circularis* in its more convex valves, proportionately wider hinge, and somewhat stronger costellae. It differs from *P. subaequata* in having finer and more even ornamentation and narrower hinge.

PIONODEMA UNIPLICATA Cooper

Plate 154, F, figures 25-33

Orthis (Dalmanella) subaequata var. *gibbosa* WINCHELL and SCHUCHERT (not *O. gibbosa* Billings), Geol. Minnesota, vol. 3, pt. 1, pl. 33, figs. 43-45, 1895.

Pionodema uniplicata COOPER, Journ. Paleont., vol. 4, No. 4, p. 379, pl. 35, figs. 1, 2, 1930.—SCHUCHERT and COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, pl. 23, fig. 12, 1932.

This species was created for *Pionodemas* having a strong fold and sulcus.

Types.—Holotype: Y.P.M. S1358; figured hypotypes: U.S.N.M. 86571a, 117341, 117342.

Horizon and locality.—Decorah formation (Spechts Ferry—Ion?) in Minnesota: At Chatfield and Lanesboro, Fillmore County; Fountain, Goodhue County; St. Paul; Minneapolis; Elmira, Olmstead County.

Decorah formation (Spechts Ferry member) in Wisconsin: At Platteville, Mineral Point (30') Quadrangle.

Same formation in Iowa: 4 miles east of Waukon, Allamakee County.

Platteville formation ? in Wisconsin: At Janesville, Rock County.

Discussion.—This species is characterized by its strong fold and sulcus, features that are not usual in the genus. *Pionodema uniplicata* is a homeomorph of *Doleroides gibbosus*, and the two occur together in the Spechts Ferry member of the Decorah formation. Specimens of *Pionodema* with strong fold coming from post-Spechts Ferry horizons may be aberrant forms of other species, but the limited representation of the species in the National Collection will not permit definite determination of this point.

PIONODEMA sp. 1

Plate 154, G, figures 34-40

Shell small, wider than long, subquadrate to subcircular in outline; hinge narrow; sides and anterior margin rounded. Costellae strong, numbering about 3 to the millimeter at the front margin.

Pedicle valve deeper than the brachial valve, strongly convex in lateral profile; anterior profile strongly arched and with steep lateral slopes; umbonal and median regions strongly swollen; anterior slope steep. Interior with long, strong, flaring dental plates surrounding the sides of a wide muscle field. Apical plate well developed.

Brachial valve moderately convex in lateral and anterior profiles; umbo sulcate, sulcus short and shallow; median region swollen; lateral slopes short and moderately steep. Interior with stout brachiophore plates flaring moderately, their anterior ends extended at an angle toward the median ridge. Shaft of cardinal process short; myophore small. Median ridge narrow, elevated, prominent, extending anterior to the middle.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------|--------|-----------------|-------|-------------|-----------|
| 86583c | 7.5 | 6.9 | 7.7 | 6.0 | 4.9 |
| 86583d | 7.1 | 6.5 | 7.7 | 6.3 | 4.9 |

Figured specimens.—86583a-c; measured specimen: 86583d.

Horizon and locality.—Chaumont formation in New York: Loose in the bed of Black River just below the third dam at head of island, Watertown, Watertown (15') Quadrangle.

Discussion.—As noted above, this species is very similar, if not identical, to *P. sulcata*.

DIORTHELASMA Cooper, new genus

(Greek *di*, two; *ortho*, straight; *elasma*, plate)

Shell minute, subrectangular in outline; sides rounded; anterior commissure strongly sulcate; unequally biconvex, the pedicle valve much deeper than the brachial valve. Surface somewhat distantly costellate. Punctate?

Pedicle valve with small teeth, curved and apsacline interarea, and small, incurved beak. Delthyrium partially closed by lateral plates.

Dental plates receding, short, divergent. Delthyrial cavity shallow; muscle field wide and short, with large diductor scars and short, narrow adductors; floor of muscle field thickened. Vascula media strongly divergent when visible.

Brachial valve with shallow and narrow notothyrial cavity bounded by slightly divergent or slightly convergent, erect brachiophore supporting plates; brachiophores long and slender; fulcral plates rudimentary; cardinal process varying from a slender ridge to a thick triangular boss filling the notothyrial cavity. Adductor scars small, elongate, the posterior pair located outside the anterior pair; no median ridge.

Genotype.—*Diorthelasma parvum* Cooper, new species.

Discussion.—This genus can be briefly characterized as having an interior like that of *Pionodema* or *Fascifera*, in combination with very unequal valves, the pedicle one being deep and the brachial valve nearly flat.

Structurally this genus is allied to *Pionodema* and is the earliest known member of the Schizophoriidae. The pedicle valve is deep and has a strongly swollen profile. The dental plates are short and somewhat bowed and surround a wide and short muscle field. No apical plate was seen in any of the specimens studied.

Inside the brachial valve the cardinalia are very close to those of *Pionodema* but are often variable between specimens. In some instances the plates are fairly closely crowded, in others they are fairly distant. The cardinal process is likewise variable. In some specimens it is a thin ridge, but in others it forms a thick, triangular boss almost completely filling the notothyrial cavity. Up to the present writing this genus has been found only in the Pratt Ferry formation, Alabama, where it is fairly common.

DIORTHELASMA PARVUM Cooper, new species

Plate 146, B, figures 5-23

Small, transversely elliptical in outline with rounded sides but a nearly straight anterior margin. Hinge wide, but not equal to the greatest shell width which is at the middle. Valves strongly unequal, the pedicle valve having the greater depth. Anterior commissure sulcate; surface costellate, costellae separated by spaces wider than the width of the costellae, about 6 costellae in 1 mm. at the front margin.

Pedicle valve moderately convex in the anterior half but strongly convex in the umbonal region. Interarea apsacline; beak low, incurved. Anterior profile broadly convex, most convex in the median region and with long lateral slopes. Umbonal and median regions swollen.

Brachial valve very gently convex in lateral profile, broadly and gently convex in anterior profile but deeply concave in the middle. Beak not prominent; sulcus originating at beak, wide and deep. Flanks gently swollen.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|--------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 2.1 | 1.9 | 3.1 | 2.2 | 1.2 |
| Paratype (117322c) | 2.2 | 2.1 | 3.4 | 2.9 | 1.4 |

Types.—Holotype: 117322a; figured paratypes: 117322b-h.

Horizon and locality.—Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—The small size, transverse outline and pionodemoid interior identify this species, but no other species of the genus is yet known to which this one can be compared.

Genus FASCIFERA Ulrich and Cooper, 1942

Fascifera ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 620, 1942.

Shell usually small, subcircular in outline, nearly planoconvex to unequally biconvex, the pedicle valve always having the greater depth. Hinge narrower than the greatest shell width; cardinal extremities obtuse. Anterior commissure sulcate to rectimarginate. Exterior costellate to fascicostellate.

Interior like *Pionodema* with flaring dental plates in the pedicle valve and a small plate at the apex of the delthyrium. Median ridge of pedicle valve only slightly developed. Brachial valve with brachiophores long and thin with discrete supporting plates converging slightly and uniting with the floor of the valve on each side of the median ridge. Cardinal process long and thin with a narrow lobate crenulated myophore. Shell substance endopunctate.

Genotype.—*Fascifera subcarinata* Ulrich and Cooper, Journ. Paleont., vol. 16, No. 5, p. 620, pl. 90, figs. 1-5, 1942.

Discussion.—The general dalmanelloid outline and profile combined with the internal features of *Pionodema* distinguish the species of this genus from other punctate shells. Most species show a fair degree of fasciculation of the costellae,

a feature that generally differentiates it from *Pionodema*. Like the latter, *Fascifera* also has the swollen, hollow costellae that are a constant feature of the Schizophoriidae. These hollow ribs are developed in varying degree among the species, some having many, others few. They also complicate the identification of species because their development in the same species is not uniform.

FASCIFERA CONVEXA Cooper, new species

Plate 268, B, figures 3-6

Small, subcircular in outline, valves subequally convex, sides and anterior margin rounded; hinge narrow. Anterior commissure rectimarginate. Surface finely costellate, costellae crowded and slender, 4 or 5 to the millimeter at the front margin. Scattered swollen costellae also present.

Pedicle valve gently convex in lateral profile with the front third to half depressed or geniculated toward the brachial valve; anterior profile somewhat narrowly swollen in the median region with slightly convex, long, and fairly steep lateral slopes. Umbo subcarinate, the carination dying out near the middle of the valve.

Brachial valve moderately convex in lateral profile, broadly and moderately convex in anterior profile. Umbonal and median regions swollen. Sulcus originating at the beak, narrow and moderately deep, extending from beak for about two-thirds the valve length, becoming lost in the anterior swelling along the margin. Flanks moderately swollen, short and steep sided next to the sulcus but with long slopes to the margins.

Brachial interior with characteristic brachiophore plates.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|-------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.9 | 8.6 | 9.7 | 6.1 | 4.8 |
| Paratype (117303b)..... | 9.4 | 8.8 | 9.9 | 7.0 | 4.5 ? |
| " (117303c)..... | 9.3 | 8.9 | 9.4 ? | 6.7 | 5.0 |

Types.—Holotype: 117303a; figured paratype: 117303c; unfigured paratype: 117303b.

Horizon and locality.—Benbolt formation in Tennessee: 1.6 miles northeast of Heiskell; on U. S. Highway 25W, 200 feet south of Claxton, both on Powell Station (T.V.A. 137-SE) Quadrangle.

Discussion.—This species is characterized by its nearly circular form, the fine, even costellae, the fairly strongly convex valves, and the small size. It differs from *F. subcarinata* and *F. dalmanelloidea* in the ornamentation and circular outline. It differs from *F. stonensis* in the small size and fine costellae.

FASCIFERA DALMANELLOIDEA Cooper, new species

Plate 149, A, figures 1-3; plate 153, D, figures 33-47; plate 153, E, figures 48-53

Fairly large for the genus, valves subequal in depth, subcircular in outline, slightly wider than long; greatest width at the middle; hinge about three-fourths

the width; sides moderately rounded; anterior margin broadly rounded; anterior commissure uniplicate to faintly sulcate. Surface fascicostellate; costellae uneven in size, 3 or 4 in 1 mm. at the anterior margin; swollen costellae forming nucleus of poorly defined fascicles.

Pedicle valve gently convex in lateral profile and with the maximum curvature just anterior to the umbo; anterior profile narrowly convex in the median region with long, moderately steep, flat lateral slopes. Beak slightly elongated; interarea curved, apsacline. Umbo subcarinate, the carination continued anteriorly nearly to the front margin as a low, narrow fold.

Brachial valve somewhat more convex in lateral profile than the pedicle valve; anterior profile gently and broadly convex and with a shallow median depression. Region just anterior to umbo and median region moderately swollen. Sulcus originating at the beak, narrow, moderately deep, continued as a narrow groove anteriorly to the front margin. Flanks gently swollen, slopes to the median sulcus long and gentle, lateral slopes gentle.

Pedicle interior with short apical plate cemented to sides of dental plates and below delthyrial edge; teeth small; dental plates strong; muscle field with elongate diductor scars and short adductor scars; median ridge faint.

Brachial interior with long, strong brachiophore supporting plates; brachiophores moderately long; cardinal process slender but nearly filling the narrow notothyrial cavity; median ridge low but extending into notothyrial cavity as a thickening.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|------------------------|--------|-----------------|-------|-------------|-----------|
| Holotype | 8.9 | 8.7 | 10.6 | 7.8 | 4.4 |
| Paratype (117305b).... | 8.8 | 8.4 | 10.4 | 7.2 | 4.1 |
| " (117304b).... | 9.6 | 8.9 | 10.1 | 6.4 | 4.6 |
| " (117306a).... | 10.7 | 10.1 | 12.1 | 8.5 | 4.9 |
| " (117304e).... | 7.2 | 6.8 | 7.6 | 5.3 | 3.0 |

Types.—Holotype: 117305a; figured paratypes: 117304a,d,e, 117305b, 117306a, 117307a,b,d, 117308; unfigured paratypes: 117304b,c, 117306b, 117307c,e.

Horizon and locality.—Bromide formation (Mountain Lake member) in Oklahoma: In the upper 10 feet of the green shale (*Platycystites* bed) in the spillway of the dam on Spring Creek, sec. 17, T. 2 S., R. 1 W., Murray County; 10 to 12 feet below the top of the purple and green shale in the cut on Oklahoma Highway 18, 1.8 miles south of Sulphur, Murray County; upper green shale (cystid bed) on west shore of Mountain Lake in E½ sec. 22, T. 2 S., R. 1 W., Carter County; 3 miles north-northeast of Springer; bed 13, ½ mile west of U. S. Highway 77, NW¼ sec. 25, T. 2 S., R. 1 E., Carter County; bed 10, same as preceding.

Discussion.—This species is very similar to *F. subcarinata* but differs in a number of minor features. The Oklahoma shell has a deeper and more persistent sulcus, a narrower and longer carination on the pedicle valve, somewhat stronger

costellation, and a shorter interarea and more erect beak. This species is rare in Oklahoma.

FASCIFERA STONENSIS (Safford)

Plate 152, B, figures 14-30

Orthis stonensis SAFFORD, Geol. Tennessee, p. 286, 1869.

Dalmanella stonensis (Safford) HALL and CLARKE, Pal. New York, vol. 8, pt. 1, p. 224, pl. 5C, figs. 4, 5, 1892.—BUTTS, Alabama Geol. Surv., Special Rep. 14, p. 126, pl. 31, fig. 16, 1926.

Shell large for the genus, slightly wider than long, with well-rounded lateral and anterior margins. Valves subequal in depth. Hinge narrower than the greatest width which is located at or near the middle. Surface marked by fine, narrow, elevated costellae of unequal size, the larger ones forming the center of more or less distinct fascicles which are best developed on the brachial valve. Costellae of first and second generations swollen. Spaces between costellae coarsely punctate.

Pedicle valve very gently convex in lateral profile, broadly convex in anterior profile, and with median region slightly carinate. Beak prominent, umbo subcarinate with carination continued anterior to the middle of the valve. Anterior portion only slightly folded. Umbonal slopes steep in the posterior part of valve, flat in profile. Interarea moderately long, gently concave, moderately apsacline.

Brachial valve slightly more convex in lateral profile than the pedicle valve and with the greatest convexity posterior to the middle. Anterior profile broadly and moderately convex. Sulcus originating at the beak, narrow, moderately deep in the posterior half, becoming wider and shallower anteriorly. Sulcus in posterior third occupied by 2 costellae. Additional costellae implanted near the middle on the outside and inside of the original 2; 2 primary costellae forming the nucleus of 2 fascicles bounding the sulcus. Areas adjacent to sulcus moderately swollen. Slopes to cardinal extremities moderately steep, slightly convex in profile.

Interior of pedicle valve with diamond-shaped area. Brachial interior with stout brachiophore supporting plates bounding a thickened notothyrial floor.

Measurements in mm.—

| | Length | Brachial length | Width | Hinge width | Thickness |
|---------------------------------------|--------|-----------------|-------|-------------|-----------|
| Hypotype (pedicle valve 118082a)..... | 12.8 | ? | 13.4 | 7.8 | 3.1 |
| “ (brachial valve 117309g).... | ? | 11.8 | 13.9 | ? | 1.8 |
| “ (117310a) | 15.6 | 14.7 | 16.7 | 10.6 | 8.0 |

Types.—Figured hypotypes: 117309b,e,g, 117310a, 117311a,b, 117312a, 118082a-c.

Horizon and locality.—Wardell and Dryden formations in Tennessee: 1½ miles northeast of Loyston, Maynardville (30') Quadrangle; 30 feet above the marble on the road along Little Sycamore Creek, ½ mile northeast of the west edge of the Howard Quarter (T.V.A. 162-NW) Quadrangle; about 2 miles northeast of Tazewell; Flint Creek, southwest of Walker Branch on west side of sharp loop, Powder Springs (T.V.A. 154-SW) Quadrangle.

Benbolt formation in Tennessee: In Raccoon Valley just east of Edgemoor, 3.1 miles southwest of Claxton, Clinton (T.V.A. 137-SW) Quadrangle.

Pierce formation in Tennessee: At old Pierce Mill on Stone River just south of Waltherhill, 7½ miles north-northeast of Murfreesboro, Rutherford County.

Ridley formation on Kensington (T.V.A. 106-SE) Quadrangle in Georgia: 1 mile south-southeast of Cove Church, 5 miles south of Chickamauga; on U. S. Highway 27, 4.3 miles north of Rock Spring.

Chickamauga limestone (=Ridley part) in Alabama: 2 miles southwest of Argo, Birmingham (30') Quadrangle.

Wardell formation (upper part) in Virginia: At Hagan, Rose Hill (T.V.A. 161-NE) Quadrangle=Woodway formation of Miller and Brosge.

Discussion.—This species is characterized by its large size, strong and subequal convexity of the valves, the subequal depth of the valves, the strong costellae with numerous swollen ribs of the first and second generations, and well-defined fasciculation. The individuals of this species attain the largest size of any known species of this genus. The stronger ribbing, the numerous, swollen ribs, more convex valves, and lesser carination of the pedicle valve distinguish this species from *F. subcarinata*.

FASCIFERA SUBCARINATA Ulrich and Cooper

Plate 152, A, figures 1-13; plate 153, A, figures 1-6; plate 153, C, figures 10-32;
plate 155, F, figure 31

Fascifera subcarinata ULRICH and COOPER, Journ. Paleont., vol. 16, No. 5, p. 620, pl. 90, figs. 1-5, 1942.

Shell of about medium size, nearly circular in outline, with rounded lateral and anterior margins. Hinge narrower than the greatest shell width which is at about the middle. Cardinal extremities obtusely rounded. Surface costellate, costellae appearing in 4 generations and somewhat fasciculate near the margins; 4 costellae occupy 1 mm. at the front margin.

Pedicle valve gently and evenly convex in lateral profile, with elevated and slightly incurved beak. Anterior profile subcarinate with moderately steep, flat-tish slopes. Umbonal and median regions subcarinate, the angularity decreasing anteriorly from the middle. Interarea slightly curved, moderately long, apsacline. Delthyrium open except for a short plate at the apex. Interior with well-developed, divergent dental plates defining shallow umbonal cavities. Diductor scars elongate, adductor field moderately wide. Vascula media short, usually indistinct, divergent.

Brachial valve more convex than the pedicle valve in lateral profile; anterior profile broadly but gently convex; umbo gently convex; sulcus originating just anterior to the umbo, narrowly U-shaped in outline, widening very slightly anteriorly and extending nearly to the anterior margin. Interarea short, anacline. Brachioophores moderately long, acute, supported by thin plates that converge to the floor of the valve on each side of the median ridge. Notothyrial cavity deep, cardinal process small.

Measurements in mm.—

| | | Length | Brachial length | Width | Hinge width | Thickness |
|----------|--------------|--------|-----------------|-------|-------------|-----------|
| Hypotype | (117319a)... | 8.6 | 8.0 | 9.6 | 7.2 | 4.3 |
| " | (117315b)... | 9.0 | 8.5 | 10.2 | 6.9 | 4.7 |
| " | (117317a)... | 10.0 | 9.1 | 10.8 | 7.7 | 4.6 |
| " | (117318b)... | 11.3 | 10.7 | 12.7 | 9.5 | 4.8 |
| " | (117318a)... | 13.9 | 12.9 | 15.4 | 9.3 | 6.2 |
| " | (117318f)... | 9.4 | 9.1 | 10.9 | 8.2 | 4.5 |

Types.—Holotype: 108198e; paratypes; 108198a-d,f,r; figured hypotypes: 117313a, 117314, 117315a,b, 117316a, 117317a,d, 117319a, 123233a, 123290a-c; unfigured hypotype: 123233b; measured hypotypes: 117318a,b,f.

Horizon and locality.—Wardell formation and Wardell part of Dryden formation in Tennessee: In the vicinity of Lone Mountain, near Tazewell, Tazewell (T.V.A. 154-NE) Quadrangle; just below and also 40 feet below the *Hesperorthis* zone in the Evans Ferry section on U. S. Highway 25E, $\frac{1}{2}$ mile north of Indian Creek, Howard Quarter (T.V.A. 162-NW) Quadrangle; at the bend of the railroad just west of Liberty Hill, Dutch Valley (T.V.A. 154-SE) Quadrangle; on the west side of the sharp loop on the road down Flint Creek, in the NW $\frac{1}{4}$ of the center subquad., Powder Springs (T.V.A. 154-SW) Quadrangle; Nicely and Palmer's store, $\frac{1}{2}$ mile east of Kate, Maynardville (30') Quadrangle; $\frac{1}{4}$ mile north of Emory road, 2 miles northeast of Hall Crossroad, Fountain City (T.V.A. 146-SW) Quadrangle.

Lower Ridley formation in Tennessee: 1 mile west of the courthouse in Murfreesboro, Murfreesboro (15') Quadrangle.

Ooltewah formation in Georgia: On Georgia Highway 2, $1\frac{1}{4}$ miles northeast of Naomi, Walker County.

Ooltewah formation in Tennessee: On the west side of Missionary Ridge, Chattanooga (30') Quadrangle; 2 miles southeast of Snow Hill Post Office, Snow Hill (T.V.A. 112-NE) Quadrangle.

Wardell formation and Wardell part of Dryden formation in Virginia: *Hesperorthis* bed at Lloyd Carter's barn $\frac{3}{4}$ mile northeast of the school at Rye Cove, Clinchport Quadrangle; elsewhere near Rye Cove, Clinchport (T.V.A. 188-NW) Quadrangle.

Discussion.—This species may be recognized by the strong carination of the umbo of the pedicle valve, by the thin lateral profile, and the moderately strong costellae. It differs from *F. stonensis* in the lesser depth and convexity of both valves, the lesser strength of the costellae, and more strongly carinate pedicle umbo.

FASCIFERA SULCATA Cooper, new species

Plate 153, B, figures 7-9

Shell of about medium size, slightly wider than long but subcircular in outline; anterior commissure deeply sulcate; fascicostellate with about 2 or 3 costellae to the millimeter at the front margin.

Pedicle valve with gently convex lateral profile; umbo strongly carinate, the

carina extending to the front margin as a narrow fold. Lateral slopes flat but long and gentle. Brachial valve gently convex in lateral profile; very gently convex in anterior profile. Sulcus originating at the umbo and widening rapidly to the anterior margin where it occupies fully half the width at the front margin. Flanks gently convex, with steepest slopes into the sulcus and long, gentle slopes to the margins.

Measurements in mm.—Holotype, length 9.7, brachial length 9.0, width 11.1, hinge width 7.6, thickness 3.6.

Types.—Holotype: 117320a; unfigured paratypes: 117320b-e.

Horizon and locality.—Upper Carters formation in Tennessee: Near Franklin, Franklin (15') Quadrangle.

Discussion.—This species differs from *F. dalmanelloidea* and *F. subcarinata* which are strongly carinate at the pedicle umbo in having a still stronger carina and one that is continued in strength to the anterior margin. It also has a stronger and deeper sulcus in the brachial valve than either of species mentioned above. *Fascifera dalmanelloidea* also has a shorter interarea, a more incurved beak, and a much narrower profile than the other species. The Carters species is more strongly costellate and fasciculate than the others. It should be noted that the generic assignment is based on subparallel plates visible at the umbo of the brachial valve when the shell is moistened.

FASCIFERA sp. 1

Plate 143, G, figures 30-36

Shell small for the genus, wider than long, somewhat rectangular in outline; sides and anterior margin rounded; anterior commissure broadly sulcate. Surface costellate, costellae uneven in size, about 4 to the millimeter at the anterior margin.

Pedicle valve deeper than the brachial valve, moderately convex in lateral profile and with the greatest convexity just anterior to the umbo; anterior profile somewhat narrowly convex in the median region and with long lateral slopes. Umbonal region convex, the narrowed convexity not extending noticeably anterior to the middle. Interarea moderately long, curved, apsacline. Beak incurved.

Brachial valve gently convex in lateral profile, broadly and gently convex in anterior profile. Umbonal region gently convex; sulcus originating at the beak, moderately wide and deep. Flanks slightly inflated.

Measurements in mm.—117321b, length 6.3, brachial length ?, width 7.3, hinge width 5.5, thickness 3.5?

Figured specimens.—117321a-e.

Horizon and locality.—Ward Cove formation in Virginia: $\frac{1}{4}$ mile west of Pounding Mill, north of U. S. Highway 19, Pounding Mill (15') Quadrangle.

Discussion.—This species is represented by a few fragmentary specimens only. A small species is indicated which is not so strongly carinate in the umbonal region as *F. subcarinata*, *F. dalmelloidea*, and *F. sulcata*. It is more strongly

costellate than *F. convexa*. The species is probably new, but better material should be had before it is named.

Genus **HIRNANTIA** Lamont, 1935

Plate 145, D, figures 24-28

Hirnantia LAMONT, Trans. Geol. Soc. Glasgow, vol. 19, pt. 2, p. 313, 1935.—A. WILLIAMS, Quart. Journ. Geol. Soc. London, vol. 107, p. 97, 1951.

This genus was proposed in 1935 by Lamont, but it has never been described or its essential characters given in detail. The allusion to its relationship to *Fardenia* is incorrect. Several specimens of the genotype in the National Collection from the Bala of Hirnant Valley, Wales, collected by Thomas Ruddy show all the important anatomical details except the character of the shell substance.

The specimens mentioned indicate a large, subrectangular shell having fine, fairly even costellae. Inside the pedicle valve the dental plates are flaring and short, surrounding a broadly oval muscle field. The diductor scars are subtriangular and moderately large; the adductor scars combine to form a wide and triangular field between the diductors.

The brachial valve is characterized by flaring, strong brachiophore supporting plates. The cardinal process is small with a moderately long, slender shaft surmounted by a small lobate myophore. The median ridge is low and extends nearly to the valve middle.

Genotype (by original designation).—*Orthis sagittifera* M'Coy, Ann. Nat. Hist., 2nd ser., vol. 8, p. 398, 1851.

Discussion.—Lamont thought that his genus was closely related to *Fardenia*, differing from that genus in "having a simple cardinal process, markedly greater convexity of dorsal valve, and radii of nearly equal calibre." The entire structure of *Hirnantia* is really quite different from *Fardenia* and indicates relationship to *Pionodema* rather than any of the schuchertellids. The pedicle musculature is like that of *Pionodema* but differs in having a wider adductor field and in lacking the median elevation usually associated with the adductors. The brachial interior is almost identical with that of *Pionodema*. The cardinal process is fairly long shafted, and the shaft is surmounted by a small, lobate myophore. The most distinctive feature of *Hirnantia*, and the feature most like *Pionodema*, is the presence of brachiophore supporting plates. These are erect and flaring. Fulcral plates are visible on one of the specimens (23960f).

Hirnantia differs from *Pionodema* in details of the ornamentation, the musculature of the pedicle valve, and the stronger development of the structures of the brachial valve. Nothing is known about the structure of the shell, whether punctate or impunctate. Because of the similarity of the structures of the brachial valve to those of *Pionodema*, *Hirnantia* is here placed in the same family as the American shell.

Types.—Hypotypes: 23960a,b,f,g.

Genus and species undet.

Plate 99, C, figure 19; plate 148, A, figures 1-4; plate 217, D, figures 6, 7

Several specimens consisting of four pedicle valves and a possible brachial valve having impunctate shell substance are considered to belong to an undescribed genus. The shells attain a width of about an inch and have a straight hinge wider or less wide than the midwidth. The pedicle valve has a moderately long interarea with a very narrow delthyrium and narrowly convex pseudodeltidium. The interior of the pedicle valve is especially characterized by dental plates so close together that they form an unusually narrow delthyrial cavity. The exterior is marked by fine costellae and a moderately deep sulcus that originates just posterior to the middle and produces a short tongue.

The brachial valve tentatively assigned here and found in association with one of the pedicle valves is ornamented like the pedicle valve but is also sulcate and apparently has a short tongue. Bisulcate shells are not common. Consequently, it is unwise to make a genus on these shells until the brachial and pedicle valve can be definitely matched. The interior of this valve is marked by 2 long and parallel brachiophore plates which bound a deep and narrow notothyrial cavity. In this cavity is a short but stout cardinal process. The internal impression suggests a long and flattish brachiophore.

Measurements in mm.—

| | Length | Brachial length | Midwidth | Hinge width | Thickness |
|-------------------------------|--------|-----------------|----------|-------------|-----------|
| Pedicle valve (117068b)..... | 12.3 | ? | 14.2 | 15.8 ? | ? |
| " " (117066)..... | 19.3 | ? | 25.0 | 21.5 ? | 4.0 |
| Brachial valve (117068a)..... | ? | 12.7 | 19.8 | 20.0 ? | 2.0 ? |

Figured specimens.—117066, 117067, 117068a,b.

Horizon and locality.—Arline formation (middle) in Tennessee: On the north side of the old road in glade, $\frac{1}{4}$ mile southeast of Friendsville, Concord (T.V.A. 138-SW) Quadrangle.

Base of Athens formation in Tennessee: Above the quarry 1 mile northeast of the courthouse in Athens, Athens (T.V.A. 125-NE) Quadrangle; $2\frac{1}{2}$ miles south-southeast of Riceville, Calhoun (T.V.A. 125-SW) Quadrangle.

Pratt Ferry formation in Alabama: 0.2 mile southeast of Pratt Ferry, Blocton (15') Quadrangle.

Discussion.—The interior details of each of the valves described above are unlike any other known genus, but until the valves can be definitely established as belonging together it is unwise to create a genus for them.

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INDEX

(PRINCIPALLY TO GEOLOGIC FORMATIONS)

[For list of families and higher groups, see table of contents (pp. ix-xi); for annotated list of genera and species, see pp. 138-186. Principal references are given in boldface type.]

A

- Amsterdam formation, 29, 30, **32**, 33
- Anomalorthis* zone, **127**, 129, 130
- Antelope Valley, Nevada, 126
- Appalachians, 10, 36
- Arbuckle Mountains, 11, **118**
- Arkansas (northern), 117
- Arline formation, 32, 39, **41**, 42, 43, 46, 50, 53, 60, 61, 64, **71**, 72, 73, 74, 75, 82, 86, 96, 124, 128
- Ashby stage, 8
- Athens formation, 33, 39, **41**, **43**, 44, 49, 56, 64, 82, 93, 123, 124
- Attalla (conglomerate) formation, 38, **45**, 55, 76
- Auburn chert, 113, **117**
- Austin Glen member of Normanskill formation, 34
- Aylmer formation, **17**, 18, 19

B

- Bacon Bend member, **45**
- Barnhart formation, 112, **116**, 117, 118
- Barrel Spring formation, **129**
- Bassler, R. S., 2, 5
- Bays formation, 38, **45**, 97
- Beckett formation, **114**
- Beekmantown formation, 7, 88
- Beldens formation, **31**, 32
- Bell, W. A., 5
- Bell, W. C., 4
- Bellefonte dolomite, 51
- Beloit dolomite formation, **113**
- Benbolt formation, 8, 39, **45**, 53, 56, 58, 59, 63, 66, 68, 69, 71, 73, 76, 82, 83, 86, 87, 90, 96, 123, 128
- Ben Hur formation, **48**, 66, 81
- Benner limestone, **48**, 66, 91
- Blackford formation (facies), 38, 40, 45, **48**, 49, 55, 56, 57, 62, 64, 72, 76, 85, 100
- Black Hills, South Dakota, 11, 125
- Black River formation (or group), 1, 7, 8, 9, 22, 27, 52, 55, 70, 92, 107, 125
- Black River Valley, New York, 22
- Black Rock formation, 15

- Blockhouse (shale) formation, 33, **49**, 93
- Bloomsdale formation, **114**
- Bolarian, 7
- Botetourt formation, 42, 43, **49**, 53, 59, 60, 61, 62, 64, 73, 74, 98, 124
- Bowen formation, **50**, 98
- Bridge, J., 2
- Bromide formation, 107, 118, **120**, 128
- Buffalo River series, **113**
- Burchards formation, **32**
- Burden conglomerate, 34
- Bureau, R., 15
- Burkes Garden member of Benholt formation, 46, **50**
- Butts, C., 2, 5

C

- California, formations in, 129
- Camarocladia* zone (beds), **59**
- Camp Nelson formation, **105**, 106
- Cane Creek formation, **51**, 56, 65, 103, 106
- Carlim limestone, **51**
- Carman quartzite, **31**, 32
- Carters formation, 51, 55, 78, 92, **102**, 103, 104, 105, 106, 107, 111, 112, 116
- Central Basin, Tennessee, 11, 99, **100**
- Centre Hall member of Nealmont formation, **52**, 71, 79
- Chambersburg formation, 15, 34, **52**, 53, 79, 81
- Champlain Valley, 10, 27, 31, 32
- Chatham Hill formation, 46, **53**, 97
- Chaumont formation, 7, 16, 19, 20, 22, **24**, 26, 27, 30, 32, 33, 110
- Chazy, 1, 7, 18, 92, 108, 123
- Chazy group, 8, 14, 15, 17, 23, **27**, 28, 31, 36, 68, 71, 103, 125
- Chickamauga limestone, 18, 43, 45, 49, **53**, 54, 55, 56, 83, 100
- Chota formation, **56**
- Clifffield formation, 48, **56**
- Clifffield group, **56**
- Cloche Island formation, 26, **27**
- Cloud, P. E., Jr., 5
- Clover member of Loysburg formation, **56**, 62, 65, 76

Coboconck, Ontario, 13, 23, 25
 Coboconck formation, 25, 26
 Cobourg formation, 18
 Cole, O. C., 3
 Collierstown formation, 56, 70, 81, 112
 Columbiana formation, 33, 44, 57, 74, 75, 85
 Cooper, B. N., 1, 2, 3, 6, 7, 9, 37
 Cow Head breccia, 13
 Criner formation, 121
 Crown Point formation, 14, 28, 31, 32, 72, 74, 87
Cryptophragmus, 7, 23, 26, 39, 58, 63, 65, 66, 89, 92, 98, 99, 101, 102, 105, 107, 108, 114
Ctenodonta bed, 111, 112
 Curdsville formation, 55, 77, 103, 104, 106, 112, 113
 Curtin formation, 57
Cybeloides bed (zone), 53, 59
Cyrtototella zone, 43, 46, 49, 59, 60, 61, 71, 84

D

Day Point formation, 14, 28, 32
 Decker, C. E., 3
 Decorah formation, 22, 110, 113, 123
Desmorthis zone, 127
 Devonian facies, 40, 41
 Dot formation, 57, 72, 85
 Douglas Lake member of Lenoir formation, 57
 Doyleburg member of Shippensburg formation, 57, 58, 63
 Dryden formation, 46, 58, 81, 96, 97, 99
 Dunbar, C. O., 3
 Dunleith formation, 113
 Dutchtown formation, 114

E

Echinospaerites-Cyrtototella zone, 71, 84
 Edinburg formation, 8, 11, 15, 34, 35, 39, 43, 46, 49, 52, 53, 59, 71, 74, 84
 Edmundson, R. S., 6
 Effna formation, 42, 43, 49, 50, 53, 56, 59, 60, 61, 64, 71, 73, 74, 75, 82, 98, 124, 128
 Eggleston formation, 61, 78
 Eidson member of Lincolnshire formation, 61, 66, 73
 Ellett formation, 62
 Elway formation, 8, 48, 57, 62, 64, 74, 77, 93, 94, 97, 120
 Eureka group, 127
 Eureka group (Dark shale with *Reuschella*), 128

Eureka group (25-foot sandstone), 127
 Eureka group (Yellow limestone), 128, 130
 Eureka quartzite, 81, 128
 Everton formation, 114, 117
 Everton-Jasper formation, 117
 Eyer (limestone) member of Hatter formation, 62, 63, 65, 66

F

Facies (in Appalachians), 38
 Fannetsburg member of Shippensburg formation, 57, 63, 91
 Farragut formation, 63, 67
Fascifera beds, 54
 Fetzer tongue, 44, 49, 64, 98
 Fillmore limestone, 130
 Five Oaks formation, 56, 64, 73
 Fleanor formation, 65, 66
 Frog Mountain sandstone, 57

G

Galena formation, 107, 113
 Gilbert, R. C., 3
 Glenburnie member of Chaumont formation, 24
 Glenn Falls limestone, 33
 Glenwood member of Platteville formation, 106, 109
 Grand Detour formation, 110
 Gratton formation, 46, 58, 65, 96
 Grazier member of Hatter formation, 62, 65, 66, 68
 Great Basin area, 11, 125
 Greencastle bed, 65
 Gull River formation, 23, 25
 Guttenberg member of Decorah formation, 27, 70, 107, 108, 110, 111, 112, 116, 117

H

Hager formation, 114, 115
 Ham, W. E., 5
 Hanson Creek formation, 128
 Hardy Creek formation, 65, 81, 103
 Hatter formation, 7, 51, 56, 62, 66
 Hatterian, 7
Hebertella exfoliata zone, 28
 Heiskell shale, 66
 Hermitage formation, 66, 103
 High Bridge, Kentucky, 11, 99, 105
 High Bridge series, 105
 Hintze, L. F., 3

Hogskin (shale) member of Lincolnshire formation, 8, 39, 40, 61, 65, **66**, 67, **72**, 73, 82, 90, 94, 123
 Holston limestone (or marble), 66, **67**, 75, 79, 86, 93
 Hook member of Macy formation, **115**
 Hostler member of Hatter formation, 7, 51, 63, 66, **68**, 69, 72
 House limestone, 130
 Housum member of Mercersburg formation, 69, 70, 78
 Hudson Valley, 10, 27, 32, 33
 Hull formation, 18, 22, 24, 31, 33, 35, 112, 124
 Humber Arm series, **13**
 Hunterian, 7
 Hurricane Bridge formation, 46, **69**, 76

I

Iberville shale, 31
 Ibex area, Utah, 130
 Ion member of Decorah formation, 30, 110, **112**, 113, 124
 Isle la Motte formation, 30, 31, 33

J

Jacksonburg formation, **69**
 Jasper formation, 117
 Joachim formation, 114, 117
 Johnson, H., 3
 Joins formation, **118**, 119, 127
 Juab limestone, 130

K

Kanosh shale, 130
 Kauffman member of Mercersburg formation, 65, **70**, 71, 78
 Kay, G. M., 1, 2, 3, 5, 22
 Kentland, Indiana, disturbed area, 11, **106**
 Kimmswick formation (Missouri), 81, 103, 113
 "Kimmswick" limestone (Tennessee), **103**
 Kindle, C. H., 3
 Kirk, E., 2, 5, 126
 Kittatinny limestone, 69
 Knox formation, 7, 54, 62, 78

L

Ladd, H. S., 5
 Lantz Mill facies of Edinburg formation, 39, 58, 59, **71**, 73
 Larrabee formation, 31, 33

Lebanon formation, 54, 55, 78, 81, 92, 98, **101**, 102, 104, 105, 106, 110, 115
 Lehman formation, 130
 Lemont member of Carlin formation, 7, 51, **71**
 Lenoir formation, 14, 29, 32, 39, 40, 41, 42, 44, 48, 57, 62, 64, **72**, 74, 78, 87, 88, 93, 94, 97, 117, 120
 Leray member of Chaumont formation, 16, 18, 20, **24**
 Leray-Rockland beds, 20
 Lévis shales, 14, 126
 Liberty Hall facies of Edinburg formation, 11, 39, 45, 53, 59, 71, **73**, 87, 98, 124
 Limestones (facies), 39
 Lincolnshire formation, 8, 15, 49, 56, 57, 59, 60, 61, 62, 64, **73**, 74, 79, 80, 84, 87, 93, 94, 95, 97, 98, 123, 128
 Little Oak formation, 43, 45, 61, **74**, 75, 85, 86
 Loeblich, A. R., Jr., 3, 5
 Long Point series, **12**, 13
 Long Savannah formation, 38, 40, **75**, 76, 81
 Lowell Park member of Platteville formation, **113**
 Lowville formation, 16, 18, 19, 22, **23**, 26, 27, 29, 32, 34, 35, 39, 52, 54, 55, 66, 102, 107
 Loysburg formation, 51, 56, 66, **76**

M

Maclurites, 7, 31, 51, 54, 55, 68, 71, 92, 127
Maclurites zone of Lenoir formation, 72, 97
 Macy formation, 114, **115**
 Magnolia member of Platteville formation, 108, 109, **110**
 Mahan formation, **76**
 Manitoulin Island, 13, 26
 Marcem formation, **76**
 Marmor stage, 8, 19, 83, 92, 108
 Martin Creek formation, 69, **77**, 87, 93
 Martinsburg formation, 70, 73, **77**, 89
 Mascot dolomite, 94
 Mazourka formation, **129**
 McGregor member of Platteville formation, 108, **109**
 McLish formation, 14, 29, 118, **119**
 Meadow marble, **78**, 79, 90, 94
 Mercersburg formation, 52, 59, 63, 65, 69, 70, **78**
 Merriam, C. W., 3, 5, 126
 Middlebury limestone, 31
 Mifflin member of Platteville formation, 108, 109, **110**
 Mingan formation, **13**, 14, 29

Mingan Islands, 13, 14
 Minneapolis limestone, 113
 Mississippi Valley, 11, 22, 108, 113
 Mississippi Valley (middle), 113
 Mississippi Valley (upper), 108
 Moccasin formation, 38, 50, 55, 78
 Mohawk limestone, 32
 Mohawk Valley, 10, 27, 32
 Montreal, 13, 15, 16
 Moore Hill formation, 26
 Mosheim formation (facies), 39, 48, 54, 64, 78
 Mountain Lake member of Bromide formation, 120
 Mount Merino member of Normanskill formation, 33
Multicostella convexa zone, 121
 Murat formation, 68, 79, 98
 Murfreesboro formation, 48, 49, 54, 55, 88, 92, 99, 100, 104, 108
 Mystic conglomerate, 8, 15, 31, 36, 127, 129

N

Nachusa formation, 110
 Napanee member of Rockland formation, 22, 24, 25
 Nealmont formation, 52, 57, 70, 71, 79, 80, 87
Nemagraptus zone, 33, 36, 75, 85, 123, 124, 125
 Neuman, R. B., 3
 Newfoundland, 10, 11, 12
 New Market formation, 79, 80, 89
Nidulites-Lambeophyllum beds, 89
Nidulites zone, 46, 59, 60, 71, 87, 95
 Nolan, T. B., 5
 Normanskill formation, 33, 34, 36
 North Cambridge, New York, 36

O

Oak Hall member of Nealmont formation, 52, 79, 80
 Oil Creek formation, 118, 119, 127, 129, 130
 Ooltewah formation, 80
 Oranda formation, 8, 34, 43, 52, 53, 56, 58, 59, 65, 70, 81, 82, 88, 89, 103, 105, 112, 125, 128
 Oregon formation, 106
Orthidiella zone, 126
 Ottawa group (or formation), 18
 Ottawa limestone, 18
 Ottawa Valley, 10, 13, 17, 18, 19, 22, 27, 33
 Ottosee formation (= facies), 66, 82, 91

P

Palliseria (Mitrospira) zone, 119, 126
 Pamela formation, 16, 18, 19, 22, 23, 25, 40, 108
 Paperville formation, 33, 44, 45, 57, 82, 83
 Pearisburg limestone, 66
 Pecatonica member of Platteville formation, 108, 109
 Peery limestone, 53, 56, 76, 83, 87, 93, 95, 114
 Pelham limestone, 56, 83
 Phillipsburg thrust slice, 31
Phylloporina bed, 112
 Pierce formation, 55, 76, 91, 92, 100, 104
 Pinesburg member of Shippensburg formation, 43, 46, 63, 83, 91
 Pioche District, Nevada, 129
 Platteville formation (group), 107, 108, 110, 113, 115
 Platin formation, 117, 118
 Platin group, 111, 113, 114, 117
 Pogonip group, 12, 15, 31, 119, 126
 Pooleville member of Bromide formation, 120, 121
 Porterfield stage, 8, 36
 Poteet formation, 84, 87, 93
 Poughkeepsie, New York, 35
 Prairie du Chien formation, 106
 Pratt Ferry (limestone) formation, 9, 36, 43, 53, 57, 75, 82, 85, 86, 98
 Prosser formation, 22, 82, 113, 124
 Prouty, C. E., 1

Q

Quebec City formation, 15, 35
 Quebec City region, 13, 14
 Quimbys Mill member of Platteville formation, 110

R

Raymond, P. E., 3, 5
 Red Knobs formation, 38, 41, 60, 86, 90, 93
 Reeside, J. B., 5
Rhynidiecta bed, 111
Rhysostrphia zone, 127
 Rich Valley formation, 36, 42, 45, 53, 56, 57, 60, 73, 83, 86, 87, 98
 Ridley formation, 47, 54, 55, 68, 69, 76, 81, 92, 97, 99, 100, 101, 104, 105, 108, 123, 128
 Rob Camp formation, 76, 85, 87, 93
 Rockcliffe member of Aylmer formation, 17
 Rockdell formation, 66, 87

Rockland formation, 7, 8, 9, 13, 17, 18, 19, 20, 22, 24, 26, 27, 30, 33, 36, 52, 59, 70, 102, 110, 125

Rock Levee formation, 110, 113, 114

Rockwood formation, 54

Rodman member of Nealmont formation, 79, 82, 87, 88, 89

Rostricellula zone of Lenoir formation, 72, 94

Row Park formation, 76, 80, 88, 89

Rysedorf conglomerate, 15, 34

S

St. Clair facies of Murfreesboro formation, 88

St. Lawrence Valley, 10, 13

St. Luke member (facies) of Edinburg formation, 71, 87, 89

St. Martin formation (member) of Aylmer formation, 14, 16, 17, 72

St. Paul group, 89

St. Peter sandstone, 106, 108, 114, 117

Salona formation, 59, 70, 77, 81, 87, 88, 89, 113

Sandstones (facies), 38

Selby member of Rockland formation, 22, 24, 25

Sevier formation (= facies), 38, 39, 47, 67, 78, 90, 93, 94

Shadow Lake formation, 23, 25

Shales (facies), 38

Shannondale member of Benbolt formation, 46, 90

Sherman Fall formation, 18, 22, 113

Shippensburg formation, 43, 46, 52, 57, 59, 63, 69, 71, 79, 91

Shrock, R. R., 3

Sillery formation, 15

Simpson group, 118

Sinclair, G. W., 3

Sinuities zone, 78

Snyder member of Benner formation, 48, 68, 91

Sowerbyites zone, 120

Spechts Ferry member of Decorah formation, 110, 111, 116, 125

Speers Ferry formation, 91

Stictoporella bed, 110

Stinchar-Balclatchie formations, 8, 43, 75, 82

Stones River group, 52, 55, 91, 92, 100

Stose, G. W., 2

Stover member of Benner limestone, 48, 92

Strasburg formation, 92

Stringtown formation, 125

Surgener formation, 38, 40, 93

Swan Peak quartzite, 130

Swift Current formation, 26, 27

T

Table Head series, 6, 8, 11, 12, 15, 28, 31, 36, 126, 127, 129

Tank Hill formation, 129

Tellico (sandstone) formation, 15, 38, 41, 43, 83, 90, 93, 94

Tetradium cellulosum, 7, 26, 34, 35, 54, 58, 65, 69, 102

Thompson Valley formation, 94, 95

Toqua formation, 94

Toquima Range, Nevada, 126

Trenton stage, 1, 9, 13, 22, 27, 35, 52, 54, 55, 83, 107, 123, 124, 125, 128

Tulip Creek formation, 118, 120

Tumbez formation, 72, 77, 94

Tyrone formation, 27, 105, 106

U

Ulrich, E. O., 1, 3, 5, 7

Utah, formations in, 11, 130

V

Valcourea-Mimella zone of Lenoir formation, 72

Valcour formation, 8, 14, 16, 18, 29, 32, 72, 74, 87, 88

Valentine member of Curtin formation, 57, 80, 94

Valley View member of Curtin formation, 57, 94

Vestal marble, 94

Viola formation, 123

W

Wahwah limestone, 130

Walker Mountain sandstone of Moccasin formation, 95

Wappinger (limestone), 35

Wappinger Creek belt, 35

Ward Cove formation, 46, 53, 56, 59, 66, 67, 69, 73, 77, 83, 85, 87, 94, 95, 123

Wardell formation, 8, 46, 48, 50, 58, 63, 65, 68, 69, 71, 73, 81, 82, 91, 96, 97, 98, 99, 100, 101, 105, 106, 108, 110, 114, 123, 128

Wassum formation, 53, 97

Watertown member of Chaumont formation, 24

Wells Creek basin, 11, 99, 104

Wells Creek dolomite, 104
Wetmore, A., 5
Weybridge member of Beldens formation, 31
Whistle Creek formation, 62, 80, 97
Whitcomb, L. D., 3
Whiterock stage, 7, 15, 28
Whitesburg formation, 11, 39, 49, 56, 73,
97, 98
Whitewood formation, 125
Wichita Mountains, 11, 118
Wilderness stage, 8, 92
Willard, B., 5
Wilson, A., 5
Wilson, C. W., 5

Witten formation, 7, 9, 19, 23, 39, 45, 48, 50,
58, 63, 69, 78, 81, 89, 90, 92, 98, 99, 102,
105, 106, 108, 115
Womble formation, 125
Woodway formation, 69, 99

Y

Yellow Branch member of Poteet forma-
tion, 85, 99
Youngman formation, 31, 32, 34, 35, 36

Z

Zell member of Macy formation, 115, 116

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